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IMPERIAL BUREAU OF ENTOMOLOGY.

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VOL. XI. 1920.

THE COCCIDAE OF SOUTH AFRICA—V.*

By CHAS. K. BRAIN, D.Sc.

Division of Entomology, Pretoria, South Africa.

(PLATES I–IV.)

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Subfamily LECANIINAE.

This subfamily comprises a large number of genera, which are, as a rule, easily distinguished by the presence or absence of secretionary matter in one form or another. All agree, however, in having the anal ring with a number of hairs and, further, in having the hind margin cleft. The anal ring is covered above by a pair of more or less triangular plates which are usually densely chitinised. The eighteen genera known to be represented in South Africa are tabulated below :—

*For Part II, see Bull. Ent. Res. ix, p. 107; Part III, *op. cit.* ix, p. 197; Part IV, *op. cit.* x, p. 95.

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Key to South African Genera.

A. Female naked, or only covered by a very thin, inconspicuous film of secretion.

B. Adult ♀ with well-developed legs and antennae.

C. Adult ♀ with posterior extremity cleft.

(1) Female flat or slightly convex, derm not very hard when mature, without polygonal areas containing pits .. .. *Lecanium*, Burm., p. 3.

(2) Female becoming hard and convex at maturity, derm with ± oval or polygonal areas containing pits .. *Saissetia*, Deplan., p. 9.

CC. Adult ♀ with posterior extremity not cleft; female with four large groups of spinnerets .. .. *Hemilecanium*, Newst., p. 14.

BB. Adult ♀ without legs or antennae .. .. .. *Aclerda*, Sign., p. 15.

AA. Female secreting a greater or less amount of cottony or powdery matter.

B. Female naked above, secretion beneath or behind the insect.

C. Female with only a narrow fringe of secretion.

(1) Female very convex, dark red, abdominal segmentation very distinct *Allopulvinaria*, gen. nov., p. 16.

(2) Female flat or slightly convex, segmentation not pronounced. *Protopulvinaria*, Ckll., p. 16.

CC. Female secreting a definite protruding ovisac *Pulvinaria*, Targ., p. 17.

BB. Female partly covered with secretion.

(1) Adult ♀ covered above, except for the median area, with a thick coat of wavy threads which project beyond the margin in all directions *Ceronema*, Mask., p. 22.

(2) Adult ♀ enclosed in a felted sac, except the cephalic extremity which is ± exposed .. ..*Lichtensia*, Sign., p. 22.

BBB. Adult ♀ entirely enclosed.

C. Sac fitting closely to body of adult ♀ at maturity and later serving as ovisac; insect leaf-infesting .. .. *Filippia*, Targ., p. 23.

CC. Sac felted, stout, conical, insect root-infesting *Conofilippia*, gen. nov., p. 25.

AAA. Female secretion waxy, glassy or horny.

B. Covering of ♀ consisting of wax, generally soft and thick; no marginal fringe nor marginal processes; female with a ± conspicuous caudal process visible on removing the wax .. .. *Ceroplastes*, Gray, p. 26.

BB. Covering of ♀ glassy, or at least brittle, thin.

(1) Scale divided into plates and striated with rows of air-cells; not causing galls .. .. *Inglisia*, Mask., p. 36.

(2) As in *Inglisia* but causing galls on roots of host-plant *Cryptinglisia*, Ckll., p. 38.

(3) Scale divided into two halves not striated with air-cells, but with grooves radiating from apex .. .. .. *Parafairmairea*, Ckll., p. 39.

(4) Scale not divided into plates nor two halves, but rough and beset with protuberances, legs and antennae well-developed, anal cleft normal *Ceroplastodes*, Ckll., p. 40.

(5) Scale not divided into plates nor two halves, ± smooth, legs and antennae rudimentary, anal cleft lateral .. ..*Idiosaissetia*, gen. nov., p. 40.

(6) Similar to *Pulvinaria* but ovisac consisting of horny membrane instead of cottony matter .. ..*Membranaria*, gen. nov., p. 41.

Genus **Lecanium,** Burm.

Adult ♀ never hemispherical nor highly convex, derm remaining comparatively soft, without polygonal areas; usually light in colour and oval; legs and antennae present, well-developed.

191. **Lecanium hesperidum,** Linn.

Coccus hesperidum, Linn., Syst. Nat. Ed. x. 1, p. 455, 1758.
Chermes hesperidum, Geoff., Hist. Abr. Ins. i, p. 505, 1762.
Calypticus hesperidum, Costa, Faun. Reg. Nap. Cocc., p. 8, 1835.
Calypticus laevis, Costa, Faun. Reg. Nap. Cocc., p. 8, 1835.
Calymnatus hesperidum, Costa, Nuov. Osserv., p. 22, 1835.
Coccus patelliformis, Curt., Gard. Chron., p. 517, 1843.
Chermes lauri, Bdv., Ent. Hort., p. 340, 1867.
Lecanium platycerii, Pack., Rep. Mass. Bd. Agr., p. 260, 1870.
Lecanium angustatum, Sign., Ann. Soc. Ent. Fr. (5) iii, p. 398, 1873.
Lecanium maculatum, Sign., Ann. Soc. Ent. Fr. (5) iii, p. 400, 1873.
Lecanium alienum, Dougl., Ent. Mon. Mag., xxiii, p. 77, 1886.
Lecanium depressum var. *simulans*, Dougl., Ent. Mon. Mag. xxiv, p. 28, 1887.
Lecanium minimum, Newst., Ent. Mon. Mag., xxvii, p. 141, 1892.
Lecanium assimile var. *amaryllidis*, Ckll., Tr. Am. Ent. Soc. xx, p. 53, 1893.
Lecanium terminaliae, Ckll., Jl. Inst. Jamaica, i, p. 254, 1893.
Lecanium nanum, Ckll., Psyche, vii, Suppl., i, p. 19, 1896.
Lecanium flaveolum, Ckll., Psyche, viii, pp. 52, 53, 1897.
Lecanium minimum var. *pinicola*, Mask., N.Z. Trans. xxix, p. 310, 1897.
Lecanium ventrale, Ehrh., Can. Ent. xxx, p. 245, 1898.
Lecanium (*Calymnatus*) *hesperidum pacificum*, Kuw., Jl. N.Y. Ent. Soc. x, p. 30, 1902.
Lecanium signiferum, Green, Cocc. of Ceylon, pt. iii, p. 197, 1904.

"Adult female bright yellow or greenish-yellow, minutely speckled with red-brown, the specks sometimes agglomerated into transverse bars, especially on the median abdominal region; in other parts tending to form dotted lines radiating from centre to margin. In older examples the ground-colour may be ochreous or pale fulvous; and the maculation may form a broad median fascia. Under surface of older examples with a deep purple-brown or red patch covering the median abdominal area, becoming concave and forming a shelter for the young larvae. Dried specimens straw-coloured and much wrinkled. Form oblong-oval, often very irregular in outline; narrowest in front; more or less concave above according to age. In some individuals, generally on those protected by some shelter, I have noticed a double median longitudinal series of raised glassy points; but they appear to be very brittle and easily lost." (Green).

Length, 2·5–5 mm.; breadth, 1·5–3 mm.

The antennae are 7-jointed, with the 3rd, 4th and 7th joints subequal. The range of measurements from South African material is as follows:—(1) 27–35, (2) 30–37, (3) 51–61, (4) 54–65, (5) 20–24, (6) 17–27, (7) 44–51μ.

The anal plates are about 155μ long.

The hairs on the antennal joints are exceptionally thin and are distributed, 2 on joint I, 2 on II, 2 on IV, 1 on V and VI, 8 or 9 on VII.

The marginal spines are short, widely spaced, simple, and nearly always have their tips recurved. There are three stigmatic spines, laterals short, median about $3\frac{1}{2}$ times as long as laterals. The stigmatic clefts are but slightly recessed, with a few simple glands.

Habitat: On citrus and a large variety of cultivated plants common throughout the Union.

Collection Nos.: 110 and 136.

192. **Lecanium africanum,** Newstead.

Lecanium viride var. *africanum*, Newst., Ent. Mon. Mag. (2) ix, p. 95, 1898.
Lecanium viride (Green), Newst., Bull. Ent. Res. i, p. 187, 1910.
Lecanium africanum, Newst., Bull. Ent. Res. vii, p. 357, 1917.

"Female adult. Colour of dried specimens often yellowish green; others are bright ochraceous, straw-coloured or pale reddish-brown; eyes black. Dorsum, especially in the younger forms, with a series of black markings, often forming a narrow loop-like pattern; these markings are however rarely present in very old examples. Form oblong oval, but the outline is often irregular; narrowed in front and moderately convex, but the margins broadly flattened, especially the cephalic portion. Antennae of eight segments, rarely of seven; formula of the former: 3 (2, 4, 5, 8) 1 (6, 7); there is a very long hair on the 2nd and 5th segments, and several shorter ones on the 8th, 6th and 7th, each with a distinctly stouter hair. Legs normal, though the anterior tarsi sometimes exhibit a faint dorsal constriction. Anal lobes attenuated distally, inner margin longest; apices with a few fine short hairs. Anal cleft slightly less than one-third the length of the body. Stigmatic cleft very slight, sometimes scarcely visible; spines three in number, rather small, the central one being about three times the length of the laterals. Marginal spines small, generally slightly curved and faintly fringed distally. There are three to four hairs of varying length near the attachment of each of the antennae, and usually four rather longer and stouter ones just in advance of the anal lobes. Derm cells oval and markedly distinct in stained preparations, but scarcely visible in unstained specimens." (Newstead).

Habitat: On citrus, Pietermaritzburg, Natal, and Nelspruit, Transvaal. On coffee, Natal coast (Fuller).

Collection No.: 106.

193. **Lecanium ehretiae,** sp. n.

Adult ♀ somewhat similar to *L. hesperidum* but rather less convex and much darker in colour, dark brown to blackish, 3·6 mm. long by 1·8 mm. broad, regularly oval. A single fringe of very short hairs is noticeable around the margin when examined with a hand lens and the surface of the body then appears mottled greyish brown in colour; the anal plates are bright brown. The dorsal surface is slightly shiny, with very indistinct and indefinite ridges and depressions.

The antennae are 7 or 8-jointed, most often 7. The following range is obtained from a series of eight measurements :—7-jointed : (1) 24–34, (2) 54–61, (3) 54–61, (4) 68–75, (5) 24–31, (6) 14–24, (7) 34–41μ ; 8-jointed : (1) 34, (2) 51, (3) 65, (4) 51, (5) 30, (6) 20, (7) 21, (8) 41μ.

Leg I : coxa 68, femur + trochanter 170, tibia 126, tarsus 75, claw 20μ. Tarsal digitules very slender, hardly perceptibly clubbed. Trochanter with an apical spine about 85μ long.

Scattered over the integument, particularly around the antennae and anal plates, are numerous hairs, the longest of which may reach 80μ in length.

The marginal spines are comparatively long (80μ), slender, slightly curved, not truncate. They average approximately 54μ apart. The stigmatic cleft has two short spurs and a median longer one (40μ). The anal plates are comparatively short (142μ) and broad (170μ across the outer angles). The anal ring has six long hairs. The derm is apparently clear, without glands.

Habitat : On *Ehretia hottentottica*, Burch. ; collected by the writer at Brooklyn, Pretoria, October 1914.

Collection No. : 117.

194. **Lecanium pumilum,** sp. n.

Adult ♀ small, about 2 mm. long, and 1·5 mm. broad, moderately convex, dark reddish brown in colour, distinctly red when younger.

Antennae 7- or 8-jointed, more often 8. The following represents the range obtained from measuring the antennae of five insects :—7-jointed : (1) 20–24, (2) 34–37, (3) 51–54, (4) 27, (5) 24, (6) 17–20, (7) 41–54μ ; 8-jointed : (1) 24–27, (2) 27–44, (3) 48–51, (4) 17–24, (5) 24–34, (6) 17–20, (7) 17–20, (8) 37–44μ.

Leg I : coxa 51, femur + trochanter 153, tibia 95, tarsus 61, claw 17μ.

The anal plate is about 150μ long. The anal ring is produced on a delicate fluted tube ; it bears 8 long bristles and several shorter ones. The margin has the usual series of simple spines about 41μ long. Stigmatic cleft with 3 straight, moderately stout spines ; laterals about 24μ long, median about 71μ. Immediately within the margin are numerous scattered small simple gland pores, many with short sharp spines.

Habitat : On the stem of a native shrub, covered by a carton shelter constructed by ants ; collected by C. P. v.d.Merwe at Robertson, C.P., May 1915.

Collection No. : 125.

195. **Lecanium elongatum,** Sign. (Plate i, fig. 233.)

Lecanium elongatum, Sign., Ann. Soc. Ent. Fr. (5) iii, p. 404, 1873.
Lecanium longulum, Dougl., Ent. Mon. Mag. xxiv, p. 97, 1887.
Lecanium chirimoliae, Mask., N. Z. Trans. xxii, p. 137, 1889.
Lecanium ficus, Mask., Ent. Mon. Mag. xxxiii, p. 243, 1897.
Lecanium frontale, Green, Cocc. Ceylon, pt. iii, p. 192, 1904.

" Female dingy pale yellowish-grey ; elongate, narrow, ends broadly rounded, side margins slightly curved out, not recurved ; surface smooth, transversely arched, longitudinally level, semi-cylindric, not carinate, a band of fairly dark

reticulation along the sides, whence, in some examples, faint dark lines radiate to the margin ; the disc occupied with a long, pale, clear, oval spot ; or in some mature specimens the scale (female) is unicolorous yellow-brown, the dorsal pale spot partly or wholly covered, and on the sides minute pale dots in place of reticulation. Underside all pale, a broad space all round the insect, a conspicuous blackish eye-spot above each antenna." (Douglas).

Antennae long, of 8 segments, range in μ as follows :—(1) 34–40, (2) 51–58, (3) 68–82, (4) 54–58, (5) 41–54, (6) 24–31, (7) 20–31, (8) 34–41.

Anal plates longer than in *hesperidum* (170μ), with the outer angles more rounded. Marginal spines a little longer than in *hesperidum* (34μ), widely spaced, averaging 70–85μ apart. Usually simple, but some with apex broadened and slightly branched and recurved. Integument, when fully chitinised, with scattered, small, oval, clear spaces. Stigmatic spines (3) ; laterals longer, straighter and more pointed than in *hesperidum*, median about four times the length of laterals, broad at the base and tapering to an acute point.

Habitat : On *Acacia melanoxylon* ; collected by A. Kelly, Joubert Park, Johannesburg, May 1915.

Collection No. : 111.

196. **Lecanium pseudelongatum,** sp. n.

Adult ♀ similar to *elongatum* but slightly less convex and darker in colour. The antennae are 8-jointed as in *elongatum*, but joints 3 and 4 are longer and 5 shorter, giving the following range :—(1) 34–40, (2) 41–51, (3) 59–68, (4) 44–61, (5) 61–71, (6) 24–34, (7) 24–27, (8) 37–41.

The most striking difference, however, is found in the marginal spines which are long (58μ) and close together, averaging 34μ apart. Stigmatic spines (3) with the laterals relatively short and slender and the median long, curved and linear.

Habitat : On native thorn tree, *Acacia caffra* (?), Pretoria ; collected by the writer, September 1914.

Collection No. : 116.

197. **Lecanium filamentosum,** Newst.

Lecanium (*Eulecanium*) *filamentosum*, Newst., Bull. Ent. Res. iv, p. 74, 1913.

Adult ♀ about 6 mm. long and 4 mm. broad, flatly convex with a slight median ridge. The colour of dried material is pale brown, with median area white as though covered by a dense layer of white secretion, which gradually fades towards the margin where numerous black dots are evident. The margin is faintly indentate, this character being intensified by the lines of black dots running to the edge and the distinct marginal glassy fringe. Seen from below the insect is brown, with four conspicuous stigmatic bands.

The antennae are 8-jointed with joint 3 remarkably long. A series of ten measurements gave the following range in μ :—(1) 57–65, (2) 68–82, (3) 150–187, (4) 75–88, (5) 65–75, (6) 34–44, (7) 31–37, (8) 54–58.

The integument is characterised by a few scattered, short, conical spines and a number of small, indistinct, " rosette " gland openings. The anal plates are about 220μ long each, with a stout apical spine and several others on the disc.

The marginal spines are comparatively short (37μ), truncate, with the extremity slightly forked. They are set at an average distance of about 50μ apart. The stigmatic clefts are deeply indented but not recessed; each with about 8 spines, of which the laterals are comparatively long and stout (60μ); the middle spine is only a little longer, but stouter. The tarsal digitules are very long and slender; those of the claw are short and very broad.

Habitat: On fig, Cathcart, C. P.; collected by L. J. Botha, July 1918.

Collection No.: 314.

198. **Lecanium proteae,** sp. n.

Adult ♀ about 6 mm. long and 4·5 mm. broad (longest specimen seen reaches 8 mm. by 6 mm. broad); colour, when alive, asphodel green (Ridgway) with very narrow margin of pale dull green yellow. The dorsum is dull coriaceous, giving the insect the colour and appearance of the leaf, the green body corresponding with the blade and the yellowish margin with the midrib or edge of the leaf.

The anal plates are small, yellowish in colour, except in old specimens, in which they are tinged with brown.

In form the insect is uniformly oval, except when situated near the midrib or edge of a leaf, when the form is irregular. Above, the body is moderately convex. Below, the insect is uniform green in colour. In boiling KOH it turns to orange yellow then reddish brown. After treatment the derm is colourless.

Anal plates about 205μ long, outer angles rounded, apices attenuated, with two apical spines, one subapical and one on the disc at about one-third the length from the apex. Anal ring with 6 long hairs. On the dorsum, immediately behind the anal opening, are two scattered groups of "rosette" glands, and there is a further transverse series on the segments immediately anterior to the two groups. The integument is otherwise clear, but has scattered hairs of varying lengths.

Stigmatic clefts shallow, with short, varying, clubbed processes.

Antennae usually 7-jointed with the fourth showing a pseudarticulation; sometimes 8-jointed; 7-jointed form: (1) 27, (2) 37–41, (3) 51–58, (4) 44–48, (5) 20–24, (6) 20–24, (7) 41–54μ; 8-jointed form: (1) 27, (2) 41, (3) 61, (4) 34, (5) 31, (6) 20, (7) 20, (8) 51μ.

Leg II: coxa 54 by 65, femur + trochanter 127 by 37, tibia 95, tarsus 17, claw 20μ.

Marginal spines very short (17μ) at very wide intervals, averaging at least 80μ apart, simple, truncate.

Male scale of the usual type, 2·0 mm. long and 1·2 mm. broad. Head and body, without genital sheath, 1·6 mm. long. Head and prothorax rufous to nearly black, glistening; body reddish, tip of abdomen and spine lighter, yellowish; legs dark, slightly darker than antennae. Caudal filaments, two, white, about as long as the head and body without antennae. Wings whitish, 1·6 mm. long, mealy, with a subcostal reddish line running three-fourths of length of wing from the base. Antennae 1 mm. long, of ten joints.

Larva, newly emerged, 0·5 mm. long and 0·25 mm. broad, orange yellow, very active.

Habitat: On leaves of *Protea*, Pretoria; common.

Collection No.: 108.

199. **Lecanium wistariae,** sp. n.

Adult ♀, mounted specimens about 3·4 mm. long by 2 mm. broad, elongate, tapering to each end. The following description, taken from the Cape Journal, was made from fresh material :—

"Young appearing August 15th; females apparently viviparous, since, while bodies are filled with eggs, only living young are seen under the scales.

"Female long oval, highly convex. Ground-colour yellow obscured by reticulations of black; the black enclosing minute, almost round patches and bounding larger patches of irregular shape and size; in a few specimens there is an obscure median stripe of yellow, but this is never well defined and generally altogether lacking. A tinge of red or rose is apparent about the whole margin of some specimens and this in a few extends as a flush over the whole dorsum."

Antennae 8-segmented; range: (1) 30–34, (2) 36–42, (3) 54–62, (4) 34–44, (5) 48–52, (6) 26–30, (7) 20–24, (8) 34–38μ.

Leg I: coxa 54 by 70, femur + trochanter 170 by 40, tibia 130, tarsus 68, claw 20μ. The tarsal digitules are slender and clubbed.

Margin with a series of slender spines, 44μ long, not truncate. Stigmatic cleft spines similar but stouter. Anal plate 125μ long.

Habitat: On wistaria, Uitenhage, collected August 1901; Cape No. 1286. Thickly clustered on thin twigs of plant; also said to be on rose and Australian myrtle.

Collection No.: 113.

200. **Lecanium durbanense,** sp. n.

Adult ♀ about 5 mm. long and 4 mm. wide, broad egg-shaped, with the extremities broadly rounded. The anterior end narrows perceptibly just in front of the middle. Body flat, mahogany-brown, with the margins and a faint median ridge somewhat darker, glossy.

When mounted, the most striking character under the low power is the chitinisation of the dorsum. In a specimen measuring 5 mm. in length a conspicuous chitinised line proceeded from the anal lobes along the middle of the dorsum to the level of the mouth-parts. A faint chitinised band was also noticeable around the margin.

The antennae are 7-or 8-jointed, with the following range in μ :—8-jointed series: (1) 27-34, (2) 34–41, (3) 37 51, (4) 34–48, (5) 41–44, (6) 27, (7) 27-31, (8) 44–51; 7-jointed series: (1) 27–34, (2) 37, (3) 37–51, (4) 37–41, (5) 41–44, (6) 37–51, (7) 48–51.

Leg I: coxa 88, femur + trochanter 187, tibia 119, tarsus 82, claw 20μ.

Anal plates about 156μ long, comparatively slender. The marginal zone appears more chitinous than the median area with the exception of the ridge previously mentioned. The chitin of the zone appears stippled; that of the median ridge has numerous small oval transparent spots. The marginal spines are very wide apart (110μ), and comprise a single row of short conical spines. The stigmatic clefts are recessed in the form of narrow deep cups; each contains two short (27μ) blunt spurs at the base.

Scattered over the integument are a few comparatively long hairs, which are particularly noticeable in the region of the antennae.

Habitat: On leaves of plant, species undetermined, Durban; collected by C. P. v. d. Merwe, April 1916.

Collection No.: 126.

Genus **Saissetia,** Deplan.

Adult ♀ usually very convex or hemispherical, and the integument very dense, dark in colour, and hard at maturity, with cell-like markings; legs and antennae well-developed.

201. **Saissetia hemisphaerica** (Targ.).

Lecanium hemisphaericum, Targ., Studii sul. Cocc. pp. 26, 27, etc., 1867.

Chermes anthurii, Bdv., Ent. Hort. p. 328, 1867.

Chermes filicum, Bdv., Ent. Hort. p. 325, 1867.

Chermes hibernaculorum, Bdv., Ent. Hort. p. 337, 1867.

Lecanium coffeae, Sign., Ann. Soc. Ent. Fr. (5) iii, p. 435, 1873.

Lecanium beaumontiae, Dougl., Ent. Mon. Mag. xxiv, p. 95, 1887.

Lecanium clypeatum, Dougl., Ent. Mon. Mag. xxv, p. 58, 1888.

Lecanium hemisphaericum var. *hibernaculorum*, Ckll., Bull. Bot. Dept. Jamaica, p. 71, 1894.

Lecanium hemisphaericum var. *filicum*, Green, Ent. Mon. Mag. xxxiii, pp. 70, 77, 1897.

Lecanium (*Saissetia*) *coffeae* var. *clypeatum*, Ckll. & Parr., The Industrialist, p. 164, 1899.

Saissetia hemisphaerica, Ckll., The Ent. Student, ii, p. 32, 1901.

Coccus coffeae, Kirkaldy, Fauna Haw. iii, pt. 2, p. 105, 1902.

Adult ♀ approaching hemispherical, ovate, with the margins somewhat flattened; dorsum smooth, shining, light to red-brown, about 2 to 4 mm. long, 1 to 2·5 mm. broad, and 1·5 to 2 mm. high. In the young forms an indistinct H is sometimes indicated on the dorsum, but this disappears in the adult, which is thus readily distinguished from *S. oleae*.

Integument with numerous clear, oval derm cells. Antennae 8-jointed, with the following range in μ: (1) 37–45, (2) 47-54, (3) 74–81, (4) 46–51, (5) 44–53, (6) 27–34, (7) 24–30, (8) 48–54.

Leg III: coxa 110, femur + trochanter 255, tibia 185, tarsus 88, claw 24μ.

Anal plates about 136μ long, triangular, with rounded corners. Marginal spines flattened at the ends, which are serrated in a variety of forms, some simple; stigmatic spines all strong and blunt; median longer than laterals.

Habitat: On pot-plants, Capetown, Grahamstown (C. P.), Durban and Pietermaritzburg (Natal), and Pretoria and Johannesburg (Transvaal).

Collection No.: 120.

202. **Saissetia oleae** (Bernard).

Chermes oleae, Bern., Mem. d'Hist. Nat. Ac. Marseille, p. 108, 1782.
Coccus olea, Oliv., Ency. Meth. vi, p. 95, 1791.
Coccus palmae, Haw., Tr. Ent. Soc. Lond. p. 307, 1812.
Coccus testudo, Curt., Gard. Chron. p. 444, 1843.
Coccus cycadis, Bdv., Ent. Hort. p. 323, 1867.
Lecanium cassiniae, Mask., N. Z. Trans. xxiii, p. 15, 1890.
Lecanium oleae var. *testudo*, Ckll., Check List, p. 331, 1896.
Lecanium oleae var. *mirandum*, Ckll. & Parr., Biol. Centr. Am. ii, pt. 2, p. 12, 1899.
Coccus oleae, Kirkaldy, Fauna Haw. iii, pt. 2, p. 106, 1902.

Adult ♀ short ovate, high convex to almost hemispherical, 2·5 to 4 mm. long, 1·5 to 3 mm. broad, and 1·5 to 2·5 mm. high. The dorsum has one longitudinal and two transverse ridges forming a distinct H, dark brown, often dotted with minute flecks of white wax. Derm with elongate cells, each enclosed in an irregular, polygonal tessellation.

Antennae 8-jointed, the segments measuring in μ: (1) 34, (2) 44–48, (3) 66–75, (4) 35–42, (5) 24–37, (6) 24–32, (7) 24–32, (8) 44–51.

Leg I: coxa 78, femur + trochanter 170, tarsus 85, claw 24μ

Anal plate about 176μ long. Marginal spines simple or flattened at apex.

Habitat: On a variety of plants, fairly common throughout the Union.

Collection Nos.: 122 and 122a.

A distinct variety of this scale, characterised by being larger and flat, without the dorsal H, is often found associated with typical *oleae* on oleander at Capetown. Its microscopic characters agree with *oleae* with the exception that antennal joints 2 and 4 are a little longer (*Coll. No.*: 122a).

203. **Saissetia nigra** (Nietn.).

Lecanium nigrum, Nietn., "Enemies of Coffee-tree," p. 9, 1861.
Lecanium depressum, Targ., Studii sul. Cocc., p. 29, 1867.
Lecanium begoniae, Dougl., Ent. Mon. Mag. xxviii, p. 209, 1892.
Lecanium nigrum var. *depressum*, Ckll., Check List, p. 332, 1896.
Saissetia depressa, King, Psyche, ix, p. 296, 1902.
Saissetia nigra, King, Psyche, ix, p. 296, 1902.
Saissetia nigrella, King, Psyche, ix, p. 296, 1902.
Coccus nigrum, Kirkaldy, Fauna Haw. iii, pt. 2, p. 106, 1902.

Adult ♀ long oval to broad ovate, low convex, shining black, 3 to 4 mm. long. Marginal spines scattered, simple, about 40μ long. Antennae of 7 or 8 segments, 7-jointed series with 4 longest, 8-jointed series with 3 longest; range in μ:— 8-jointed series: (1) 27, (2) 37-41, (3) 58–68, (4) 34-44, (5) 34–41, (6) 24, (7) 24, (8) 51–54; 7-jointed series: (1) 27, (2) 34, (3) 54, (4) 68, (5) 24, (6) 20, (7) 58.

Leg I: coxa 58, femur + trochanter 170, tibia 116, tarsus 68, claw 20μ.
Anal plate about 170μ long.

Habitat: On *Ficus* spp., Bayville, C. P., and Natal coast.

Collection No.: 123.

204. **Saissetia perseae,** sp. n.

Ova and larvae small, purplish red in colour, found beneath dry body of adult ♀ attached to mid-rib of leaf. Larvae about 0·35 mm. long and 0·18 mm. broad, almost oval, slightly broadest between the second and third pairs of legs, broadly rounded in front and regularly cleft behind, with two caudal spines equal in length to the greatest width of the body. The eyes are deeply pigmented.

The antennae are six-jointed; segment 2 a little shorter than 1; 3 is long (27–30μ), almost equal to 6; 4 and 5 are shorter and almost equal (13μ and 15μ). There is a distinct notch near the distal end of 3, and another at about the middle of 5, from which points long hairs arise. The terminal segment has a long apical spine, two others of about three-fourths its length, and several shorter hairs. Claws simple; upper digitules long, straight, with small globular knobs; lower digitules shorter, also with small clubs. Margin with thin short spines; at level of spiracles on each side there are two stout blunt spines, about 15μ long, pointing obliquely backwards. Anal bristles reaching level of hind-margin, or nearly so.

Adult ♀ 4·2 mm. long, 3 mm. broad, pointed at each end, but more so in front, with the dorsum quite flat. In colour it is blackish brown, and of a dull matt appearance, entirely without design or marginal appendages. The margin is entire, with a very slight notch at the two spiracles on each side. Seen from below the extreme margin is thin; the legs and antennae pale, and there are four faint lines, two on each side, representing stigmatic bands. There is no trace of an anal cleft when examined with a hand-lens. When crushed the body-contents are purple in colour. Placed in hot KOH solution the body becomes hard and curls so much that it is difficult to make a satisfactory mount.

The integument on the dorsum is extremely dense, hard and brittle when cleared; that of the venter is thin, hyaline, and very delicate. The legs and antennae are colourless. The anal cleft is entirely absent, with the exception of a very short space posterior to the anal plates. Beyond this it is merely indicated as a line between the polygonal "cells" of the dorsum. Polygonal cells with straight sides, each with a very small transparent spot appearing as a point under the microscope. The space occupied by the anal plates is clear, faintly yellow, a striking contrast to the deep brown of the remainder of the dorsum when cleared. The inner face of the plates is straight; the outer margin regularly curved to the tip giving them a broad heart-shape. (Fig. 243). The polygonal cells are fairly uniform in size to near the margin where they gradually disappear into the thin structureless marginal area. Eye-spots distinct.

The antennae are 8-jointed. Joints 2, 4, 6 and 7 sub-equal: 1 a little shorter, 3, 5 and 8 longer. Measurements in μ: (1) 30, (2) 37, (3) 47, (4) 30, (5) 50, (6) 30, (7) 27, (8) 47.

Habitat: On upper side of leaf of avocado pear (*Persea gratissima*), from Mrs. Godwin, Durban, May 1916.

Collection No.: 103.

This species is remarkable for the hardness of the integument at maturity and the fact that the anal cleft is obsolete in the later stages. It differs from *Hemilecanium*, however, in lacking the four perforate areas on the dorsum.

205. **Saissetia kellyi,** sp. n.

Adult ♀ almost circular, but rather wider than long (11·5 mm. by 13 mm.), flat, closely adherent to stem, deep chestnut in colour, with the dorsum matt, without ridges or lines of any kind, but flatly bounded to thin margin, often covered with dust, etc., so as to appear like a large flat blister on the bark. Younger specimens rather lighter in colour, with faint radiating ridges from the somewhat raised median area.

The following particulars concerning antennae, legs, and microscopic characters in general, refer to insects measuring approximately 7 mm. long, i.e., before chitinisation was fully complete.

Antenna 9-jointed, range in μ: (1) 48–54, (2) 85–102, (3) 129–153, (4) 75–85, (5) 58–65, (6) 105–116, (7) 44–51, (8) 34–48, (9) 74–79.

Leg I: coxa 153, femur + trochanter 357, tibia 245, tarsus 153, claw 31μ.

Anal plate about 320 μ long. The margin has a single row of short, stout, conical spines. Stigmatic cleft with 3 gradually tapering spines, laterals about 50μ, median about 136μ.

Around the body, just within the margin, is a series of complex, tubular glands, about 40 in number, distributed at almost regular intervals. Scattered over the integument, particularly near the margin, are numerous, short, stout, glandular hairs. The thin marginal area has the usual ± straight, sided polygonal cells; the median area has elongate oval cells much like those of *Hemilecanium theobromae*, Newstead.

Habitat: On thick stems of *Acacia melanoxylon*, Pietermaritzburg, Natal; collected by A. Kelly, June 1915.

Collection No.: 118.

The anal cleft is quite obsolete in mature specimens. This character, together with the two distinct types of cells on the dorsum and the 9-jointed antennae, reminds one of the type species of the genus *Hemilecanium*, Newst., but the absence of the four perforate areas preclude this species from that genus.

206. **Saissetia persimilis,** Newst. (Plate i., fig. 234).

Lecanium (*Saissetia*) *persimile*, Newst., Bull. Ent. Res. vii, p. 362, 1917.

"Female, adult. Not differing appreciably in its external form, colour, and density of chitin from *Lecanium* (*Saissetia*) *oleae* (Bernard), but in two examples the dorsum was covered with a fine dusky-white, mealy secretion. The median longitudinal and two transverse ridges, forming roughly the letter H, well marked in two specimens, but absent in another. Anal cleft completely fused. Anal lobes attenuated, outer angle broadly rounded, inner edge much the longest; apex bluntly pointed with one or two short spines. No stigmatic clefts; spines three, the central one slightly more than twice the length of the laterals. Antennae well developed, of eight segments. Legs rather slender; lower digitules very robust, incrassate proximally, dilated distally. Derm thickly studded with small, but well-defined, oval and translucent cells; these are much more crowded together at the margin and also larger." (Newstead).

Newstead states that *Lecanium* (*Saissetia*) *sylvestrii*, Leon., has some similarity to *persimile*, but the former has 7-jointed antennae and *three* transverse ridges across the dorsum.

Habitat: On *Combretum*, Muckleneuk, Pretoria; collected in October 1914.

Collection Nos.: 115 and 124.

207. **Saissetia subpatelliforme,** Newst. (Plate i., fig. 237).

Lecanium (*Saissetia*) *subpatelliforme*, Newst., Bull. Ent. Res. vii, p. 366, 1917.

Adult ♀ large, reaching 7 mm. long, 5 mm. broad at the base and 3·5 mm. high, very convex but ± conical, with the margin at the base slightly produced as a rounded ridge. The colour is dark castaneous to almost black, slightly shining, and without white flecks. There is no dorsal H, nor prominent ridges of any form (fig. 237).

Younger forms are lighter in colour, flat, disc-like, with the margins slightly raised and rounded and the median area wrinkled. The anal cleft is apparently obsolete and the anal lobes inconspicuous.

Antennae 8-jointed; range in μ: (1) 37–47, (2) 35–51, (3) 75–78, (4) 54–58, (5) 41–54, (6) 24–27, (7) 17–20, (8) 51–58.

Professor Newstead's description, omitting figure references, is as follows:

"Female, adult. Varying from broadly to narrowly ovate, centre generally highly gibbose; surface rather roughened or slightly rugose, often with widely separated patches of secretion, especially at the sides; dorsum (gibbosity) often shining. Derm cells of the median and sub-median areas small, ovate and widely separated, those near the margin much larger. Marginal spines of two kinds: (1) long and rather stout, dilated and divided on both sides; (2) similar, but only about half the length of the long ones. Stigmatic clefts practically obsolete; spines three, the laterals small, stout and pointed; central one missing in all the preparations. Eyes well defined. Antennae of seven or eight segments (both forms present in one ♀). Legs well developed; tarsus almost equal in length to the tibia; lower digitules stout, upper pair normal. Anal lobes with the base and outer edge of equal length, approximately. Anal ring of eight hairs. Anal cleft varying in length from a little less than a third to one-third the length of the body. Length, 3·8–5·2 mm."

Habitat: On stems of *Cedrela toona*, Salisbury, Southern Rhodesia; collected by Rupert Jack, June 1917. Also on stems of *Syringa*, Salisbury; collected by Rupert Jack, February, 1909 (119a).

Collection Nos.: 119 and 119a.

208. **Saissetia oculata,** sp. n.

Adult ♀ elongate, 8 to 9 mm. long by 4 mm. wide, moderately flat, dull, buff to brown in colour, with the eye-spots and anal plates darker, almost black; margin more chitin-brown, with a conspicuous fringe. Dorsum with rows (3) of hairs similar to fringe. Eyes distinct, almost circular, about 165μ in diameter, with darker central prominence. Integument with faint oval cells, widely scattered. In the specimens examined these are most conspicuous around the anal lobes,

the point from which the chitinisation of the integument appears to spread in the LECANIINAE. This suggests that, although the insects examined are adult, they may not be quite mature.

Antennae of 8 segments, range in μ: (1) 37–41, (2) 48–58, (3) 102–112, (4) 58–68, (5) 61–68, (6) 31–34, (7) 27–34, (8) 44–51.

Leg I: coxa 88, femur + trochanter 238, tibia 170, tarsus 102, claw 24μ.

Margin with conspicuous fringe of long spines (136μ) with tips saw-like or finger-like. Dorsum with three longitudinal rows of long (143μ) spines. Anal plates long, tapering (280μ). Stigmatic clefts inconspicuous with two very short spines and one longer (about half the length of marginal spines).

Habitat: On grapevine, Durban; collected by C. P. v. d. Merwe, May 1917.
Collection No.: 321.

Genus **Hemilecanium**, Newstead.

"Adult female with the posterior extremity not cleft. Anal orifice placed near the middle of the dorsum and closed above with a pair of hinged plates as in *Lecanium*. Larva and nymph with a distinct anal cleft as in *Lecanium*. Female in all stages with four large dorsal groups of compound spinnerets." (Newstead).

209. **Hemilecanium theobromae**, Newst. (Plate i., fig. 238).

Hemilecanium theobromae, Newst., Jl. Econ. Biol. iii, pt. 2, p. 39, 1908.

Professor Newstead's description, omitting figure references, is as follows:—

"Adult female broadly ovate or sub-circular; margins broadly flat, central area suddenly elevated, with strong irregular prominences. The whole of the dorsal area covered with a thin but dense layer of ochreous meal-like wax, but the prominences of the dorsum are generally denuded, apparently through abrasion, appearing through the secretion as shining, piceous, irregularities. Cuticle shining dark piceous on the central elevated area; dark castaneous and strongly rugose at the margins. Venter covered with a rather thick layer of white fibrous secretion. Anal cleft obsolete, but there is usually a faint emargination at the posterior extremity. Anal orifice placed just within the broad elevated dorsal zone at about one-third of the distance from the posterior margin. Derm cells of two distinct types; those of the dark central area narrowly elongate with an apical pore, those of the pale broad margin of the ordinary polygonal type. There are also four groups of spinnerets; two towards the anterior and two towards the posterior extremity, each group composed of several hundred spinnerets forming well-defined dark chitinised areas. Antenna of nine segments, of which the third is the longest; there are a few long hairs on the four terminal segments; formula 3, 4 (5, 2, 9) 6, 1 (7, 8). Legs highly chitinised; slender but small compared with the size of the insect; coxa almost equalling the length of the femur; digitules simple. Marginal spines with their broad bases suddenly contracted, each fitting into a well-defined socket, the latter being attached to a short subcutaneous tube. Stigmatic channels and spines absent.

"Length 13–15 mm.; width 12–13 mm.

"Second stage female broadly ovate, slightly narrowed posteriorly, marginal spines continuous, resembling those in the adult. Antennae of seven segments, the third being the longest, the rest of the segments subequal in length. Legs scarcely longer than the antennae; coxa rather broad. Mentum uniarticulate. Groups of spinnerets occupying relatively the same position as in the adult, but there are only about 60–70 individual spinnerets in each group; they are also larger and more distinctly separated than in the adult. Derm in the region of the anal cleft finely squamose, with a large subcutaneous tube; there is also a similar tube just within the margin opposite the anterior stigmata.

"Larva elongate; position of the compound spinnerets as in the adult and nymph. Mentum monomerous. Antennae of six joints, the third equalling the length of the fourth, fifth and sixth together. Marginal spines forming a continuous series."

Habitat: On tree euphorbia, East London, and stems of oleander, Capetown (Fuller, 1898).

Collection No.: 107.

Genus **Aclerda,** Sign.

Adult ♀ naked, a mere sac containing eggs at maturity, with normal mouth parts, but legs and antennae absent.

Larva greatly elongated, with parallel sides.

210. **Aclerda digitata** (Ckll.).

Pseudolecanium digitatum, Ckll., Ann. Mag. Nat. Hist. (7) ix, p. 24, 1902.

Aclerda digitata (Ckll.) Fernald, Catalogue, p. 210, 1903.

Professor Cockerell's description is as follows:—

"♀, pyriform, with the hind end pointed; about 2½ mm. long; dark ferruginous, shiny, producing some cottony material. End of abdomen strongly chitinized, with the form usual in the genus. The diagnostic characters, as in all species of the genus, are derived mainly from the larva, the female being a mere bag of eggs.

"Larva extremely long and narrow, length 600, breadth 160μ. Anterior extremity truncate, crenulate, with six short blunt, finger-tip-like spines; a row of fifteen blunt spines down each side of body; no dorsal spines; legs well developed, anterior tibia 60, its tarsus 30μ long; the tibia has a constriction about 27 from base, making it look almost 2-jointed, this being more or less apparent on all the legs; tarsal digitules long, with small knobs; claw-digitules shorter, filiform, knobbed. Antennae 24 apart at base and 30μ from anterior end of head; 6-jointed, joints measuring: (1) 18, (2) 12, (3) 27–33, (4) 20, (5) 21, (6) 30. Anal ring small, circular, without bristles on its margin, but posterior to it are set four bristles, of which the inner two are shortest; anterior to anal ring is a row of four finger-like blunt spines; on each side is a caudal bristle, about 190μ long, and beyond each of these a pair of finger-like spines; anterior to and a little laterad of each caudal bristle is a small round gland. The last two segments have each a pair of bristles on the ventral surface, those on the last being twice as long as those on the penultimate segment."

Habitat: On grass, Natal; collected by C. Fuller, 1901. This species has not been found again.

Collection No.: 134.

Genus **Allopulvinaria,** nov.

Adult ♀ naked above, very convex and distinctly segmented. Lower surface concave, filled with a compact powdery mass of wax which projects around the margins. Antennae somewhat rudimentary, of 4, 5 or 6 segments. Legs well developed. Anal ring with numerous (12?) hairs.

Larva elongate and narrow ; anal tubercles produced, each with one long seta.

Type, *A. subterranea,* sp. n.

211. **Allopulvinaria subterranea,** sp. n. (Plate vi, fig. 246).

Larva active, pale pink, eyes pigmented, body elongate and narrow. Anal tubercles long, each with one long seta.

One-fourth grown ♀ with 4-jointed antennae, and marginal hairs as in *Lecanium.*

Adult ♀ viviparous, 7 mm. long, 4·5 mm. broad and 4 mm. high. Dorsum roundly arched ; segmentation distinct, the segments roundly ridged.

The body is red, faintly flecked with white wax. Underside flatly concave, abdominal portion plainly segmented. Legs small, brown. Anal plates small, brown, from between which protrudes a double fine pencil of white wax. Lower concavity of body filled with cushion of white wax which extends slightly beyond the margin of the body ; this is not cottony but compact. No eggs were seen, but larvae were present in the white waxy cushion and in the body of the ♀.

Antennae 4, 5, or 6-jointed, usually 5. Anal ring with numerous (12?) hairs.

Anal plates raised, appearing excavate so as more or less to enclose the anal tube from the sides as well as above. Anal groove closed. Integument with numerous simple glands and short acute spines scattered over the surface ; the former especially noticeable in transverse series across the segments.

The following measurements may be useful for comparison.

Antennae : (*a*) 4-jointed type :—

	I	II	III	IV.
(a)	40	27	61	34μ
(b)	34	40	65	54μ

(*b*) 5-jointed series, range in μ :—(1) 34–45, (2) 34–40, (3) 51–68, (4) 15–34, (5) 23–40 ; (*c*) 6-jointed form, e.g. (1) 41, (2) 34, (3) 61, (4) 17, (5) 10, (6) 20.

Leg II : coxa 81 by 108, femur + trochanter 150, tibia 74, tarsus 74μ.

Habitat : On stems of " quick " grass, near bank of stream ; collected by T. L. Watermeyer, Jonkershoek, Stellenbosch, C.P., July 1917.

Collection No. : 138.

Genus **Protopulvinaria,** Ckll.

The few species which have been described in this genus are similar to *Lecanium* in their early stages, but may be readily distinguished at maturity by the small white ovisac which is secreted beneath the adult ♀. In the normal condition this is but slightly larger than the body of the female and protrudes as a white ring around the margins of the body (fig. 248).

This genus is included in *Pulvinaria* by Mrs. Fernald in her Catalogue (p. 128), but it would appear that its correct position is between *Lecanium* and *Pulvinaria.*

212. **Protopulvinaria piriformis** (Ckll.), Lefroy. (Plate ii, fig. 244; iv, fig. 248.)

Pulvinaria (*Protopulvinaria*) *pyriformis*, Ckll., Jl. Trin. Nat. Club, i, p. 309, 1894.

Pulvinaria (*Protopulvinaria*) *pyriformis*, Ckll., Jl. Trin. Nat. Club, ii, p. 307, 1896.

Pulvinaria newsteadi, Leon., Riv. Pat. Veg. vi, p. 279, 1898.

Pulvinaria pyriformis, Ckll., Psyche, viii, p. 311, 1899.

Protopulvinaria pyriformis, Lefroy, Scale Ins. Lesser Antilles, p. 43, 1901.

Pulvinaria pyriformis, Fernald, Cat., p. 138, 1902.

Pulvinaria plana, Ldgr., Jahrb. Hamb. Wiss. Anst. xxxiii, p. 34, 1911.

Protopulvinaria piriformis, Ldgr., Die Schildläuse, p. 199, 1912.

Ovisac slightly larger than the body of the adult ♀, from which it extends as a uniform ring around the margins (fig. 348). Ova pale greenish white, regularly oval.

Adult ♀ about 3 mm. long and about as broad slightly behind the middle; broadly rounded behind, suddenly narrowing in front so as to be short pear-shaped or drop-shaped. The margins of the body are flat; the central part is flatly rounded. In living specimens the general body colour is yellowish or pinkish with the margins reddish brown. The subdorsal area is irregularly suffused with mauve or violet. The anal cleft is deep, extending almost to the centre of the body, but the sides are in close proximity, so that the posterior margin in most cases appears uniformly broadly rounded. The anal plates are very long and very narrow and are brownish in colour. Dead, dry specimens are pale to deep brown according to age. When stained, cleared and mounted the following characters may be noted:—

Antennae 7-jointed; range in μ: (1) 27–31, (2) 37–44, (3) 44–51, (4) 51–54, (5) 20–24, (6) 20–24, (7) 51–54.

Leg I: coxa 75, femur + trochanter 170, tibia 109, tarsus 54, claw 20μ.

Leg II: coxa 99, femur + trochanter 180, tibia 112, tarsus 68, claw 24μ.

Anal plates very long (470μ) and narrow (fig. 244).

Marginal spines short, thin, with ends deeply branched, or occasionally bifid from base, in a close-set series. Stigmatic spines 3, laterals short and acute, median two or three times as long. Young form, about 1·2 mm. long, oval, translucent, appearing faintly greenish yellow, with six deep purple lines radiating from median area to margin, the four posterior being nearer together than the anterior two.

Habitat: On undersides of leaves of avocado pear (*Persea gratissima*); collected by A. Kelly, Pietermaritzburg, April 1916.

Collection No.: 77.

Genus **Pulvinaria**, Targ.

"Adult female resembling *Lecanium* in the early stages and until the commencement of oviposition, when a loose cottony ovisac is secreted from below the posterior extremity of the insect, for the protection of the eggs. The body of the insect is tilted up during the formation of the ovisac, and often becomes much shrivelled and distorted, finally remaining as a small shapeless scale at the anterior extremity of the mass of ovisac. It is sometimes rendered still more inconspicuous by the partial overlapping of the secretionary matter, but is never completely enveloped. In all purely structural characters there is nothing to distinguish species of this genus

from those of *Lecanium*, so much so that, until the period of oviposition, it would be impossible to determine whether an individual should be placed in the one or the other genus." (Green).

213. **Pulvinaria aristolochiae,** Newstead. (Plate ii, fig. 242).

Pulvinaria aristolochiae, Newst., Bull. Ent. Res. viii, p. 19, 1917.

Adult ♀, immediately prior to forming the ovisac, about 8 mm. long and 4·5 mm. broad, with thin margins and the dorsum rising to a distinct central prominence : colour brown, with darker markings. The margin is supplied with a short fringe of thin pale hairs : from this to the raised centre extend a number of dark lines.

Male puparium about 3 mm. long, moderately convex, dull white, not glassy, with a distinct transverse ridge about the middle. Two white filaments protrude from the posterior extremity some days prior to the emergence of the adult ♂. Adults were emerging in July 1916.

Antennae 8-jointed, range in μ :—(1) 57–75, (2) 68–75, (3) 187–190, (4) 95–102. (5) 78–85, (6) 34–47, (7) 24–34, (8) 41–44.

Leg I : coxa 185, femur + trochanter 400, tibia 262, tarsus 123, claw 34μ.

Anal plate about 250μ long. Marginal spines short (27–35μ), many appearing truncate.

As Professor Newstead did not have the opportunity of examining living material the above particulars are given to supplement his description which is as follows :—

" Female, adult. More or less cordate in outline and rather flattened ; dorsum almost completely covered with a well-defined layer of flake-like wax which varies in colour from dirty grey to greyish brown. Antennae of eight segments ; 3rd, 4th and 5th unusually long, the two first-named swollen distally ; 3rd about twice the length of the 4th ; three long hairs on 2nd, one of which lies (in three examples) close up to the succeeding segment ; there is also a long distal hair on the 3rd ; two on the 5th ; a single spine on the 6th, 7th and 8th, the last-named also with a few very short hairs. Legs stout, long ; tarsus relatively very short, less than one-third the length of the tibia ; lower digitules long and very broadly spathuliform. Marginal spines stout, pointed, and placed rather close together ; stigmatic spines broken away in all the specimens, their points of attachment being continuous with the marginal series. Submarginal pores very large, continuous, but rather widely separated. Anal lobes with four stout spines near the apex, on the inner edge. Anal cleft short, usually a little less than one-sixth the entire length of the body. Anal ring with eight hairs. No derm cells present ; but there are numerous circular spinnerets (? ventral), each having an inner concentric ring. Length 5·7–7·6 mm.

" Ovisac pure white and closely felted, long and generally tortuous. Length 10–20 mm."

This insect shows great similarity to *P. jacksoni*, Newstead. Both have remarkably long joint 3 to the antennae, which in *jacksoni* is almost 120μ, in *aristolochiae* about 180μ. Further both produce extremely long ovisacs.

Habitat : On stems of *Erythrina caffra* Thunb., (Kaffir-boom), Natal Coast.

Collection Nos. : 79 and 84.

214. **Pulvinaria floccifera** (Westw.).

Coccus floccifera, Westw., Gard. Chron., p. 308, 1870.

Pulvinaria brassicae, Ckll., Can. Ent. xxvii, p. 135, 1895.

Pulvinaria floccifera, Green, Ent. Mon. Mag. xxxiii, p. 72, 1897.

Pulvinaria phaiae, Lull, Ent. News, x, p. 237, 1899.

Pulvinaria floccosa, Newst., Jl. Roy. Hor. Soc. xxiii, p. 26, 1900.

Completed ovisac about 6 mm. long and 3 broad, with parallel sides and rounded extremity; pink in colour, from the numerous ova which are of that colour; the small amount of white cottony matter which is incorporated in the mass is inconspicuous owing to the large number of eggs.

♀, young stage: about 2 mm. long, translucent greenish yellow, with the median dorsal area suffused with a pinkish or brownish tint.

Adult ♀ about 3 mm. long and almost as broad, moderately convex. The margins are pale translucent greenish yellow, the median dorsal area is reddish brown and the whole dorsum is more or less wrinkled. The crests of the ridges, especially those running to the margin, blackish brown. Anal plates small, of the same colour as the dorsal area or slightly paler. When the ovisac is almost complete, the body of the ♀ has shrunken to such an extent that the brownish part of the dorsum is not conspicuous, while the black crests of the ridges are close together and thus give the insect a much darker appearance.

Antennae 8-jointed, range in μ: (1) 34–38, (2) 44–51, (3) 65–72, (4) 34–44, (5) 34–41, (6) 24–27, (7) 24, (8) 44.

Leg I: coxa 78, femur + trochanter 190, tibia 163, tarsus 102, claw 24μ.

Upper digitules very long, slender, with spherical knobs. Lower digitules stout, normal. Anal plate about 145μ long. Just in front of the anal plates there are a few scattered, "rosette" glands and two pairs of long (108μ) hairs. Marginal spines about 50μ long and 100μ apart, slender, often with finely divided tips, alternating with a submarginal row of similar hairs of about half the size. Stigmatic spines comparatively short and stout, with the outer ends tapering to blunt points. From these to the spiracles extends a double row of small rosette glands.

Puparium of ♂ of the usual type with the segments of the plates very distinct. The whole puparium is opaque white, appearing finely striate in a longitudinal direction.

Habitat: On a native plant (*Solanum* sp. ?) Durban; collected by C. P. v. d. Merwe, July 1916.

Collection No.: 82.

A very large percentage of the young forms (about 1·5 mm. long) are very convex and shiny black, obviously parasitized.

215. **Pulvinaria jacksoni,** Newst.

Pulvinaria jacksoni, Newstead, Jl. Econ. Biol. i, p. 155, 1908.

Professor Newstead's description is as follows:—

"Ovisac from two and a half to seven times the length of the female; breadth equal to the width of the insect; low convex, sides parallel; closely felted, tough and web-like in texture. Length 16·75–42 mm.

" Adult female—Dried examples sienna brown or dull ochreous; the pale examples with yellowish mottlings indicating the position of the derm-cells. Form normal. Antennae of eight segments, the third being much the longest; last four subequal; there is a very long hair on the third and fifth, the one on the former the longest. Legs stout; trochanter about one-third the length of the femur, with a very long apical hair; digitules to claws and tarsi normal. Derm with very small inconspicuous glands. Marginal spines short, closely set, truncate, the ends often notched. Stigmatic clefts with pointed spines and two large tubercles.

" Male puparium, much stained with brown, normal in shape, but thick and unusually wax-like in appearance; dorsal plate with one large central, white, wax-like felted spot and several brownish tubercles immediately beyond it. Length 2·25 mm."

The following measurements are added for comparison with the other South African species :—

Antennae 8-jointed; range in μ: (1) 48–54, (2) 54–68, (3) 102–116, (4) 68–75. (5) 61, (6) 31–34, (7) 31–34, (8) 37–41.

Leg I: coxa 139, femur + trochanter 354, tibia 230, tarsus 108, claw 27μ.

Anal plate about 240μ long.

Habitat: On *Trichilia* sp., Durban; collected by A. Kelly, May 1918.

Collection No.: 79a.

216. **Pulvinaria lepida,** sp. n.

Adult ♀♀ with ovisacs clustered on stems and leaves of grass.

Adult ♀ averaging 2 mm. long by 1·3 mm. broad, moderately arched, light brown in colour, dorsum with transverse wrinkles; marginal area flecked with white wax. Ovisac white, elevated, extending behind the insect for about the length of ♀ body, faintly fluted on upper surface.

Numerous ♀♀ parasitised. Mounted specimens contain numbers of well developed embryos.

Antennae variable, of 7 or 8 segments; terminal joint appearing truncate; range in μ :—7-jointed: (1) 34–37, (2) 37–48, (3) 54–65, (4) 70–82, (5) 24–27, (6) 24–27, (7) 37–41; 8-jointed: (1) 34–37, (2) 44–48, (3) 51–58, (4) 34–41, (5) 44–48. (6) 24–27, (7) 24–27, (8) 37–41.

Leg I: coxa 78, femur + trochanter 187, tibia 153, tarsus 102, claw 24μ.

Anal plate about 153μ long, with 5 comparatively short hairs at the apex. Marginal spines in a single row, simple, pointed, about 41μ long and 20–30μ apart, straight or only slightly curved. Stigmatic spines: laterals short, acute; median stouter, longer, blunt.

Habitat: On stems and leaves of common veld grass, Standerton and Pretoria (K. Munro).

Collection Nos.: 139 and 328.

217. **Pulvinaria mesembryanthemi** (Vallot), Sign. (Plate i, fig. 235).

Pulvinaria mesembryanthemi, Vall., Bull. de Ferussac, xxii, p. 469, 1830.

Calypticus mesembryanthemi, Costa, Ann. Acad. Asp. Naples, p. 273, 1844.

Pulvinaria biplicata, Targ., Catalogue, p. 34, 1869.

Pulvinaria mesembryanthemi, Sign., Ann. Soc. Ent. Fr. (5) iii, p. 39, 1873.

Adult ♀ to time of forming ovisac, and younger stages, green, of the same tint as the fleshy leaf of *Mesembryanthemum edule*, its most common food-plant; attaining a length of 5 mm. and an almost equal breadth, moderately convex, dorsum smooth.

As the ovisac is produced the body of the ♀ becomes yellowish and later yellowish brown, much shrunken, with four transverse ridges and, ultimately, contorted or bent backward (fig. 235).

Antennae 8-jointed; range in μ: (1) 48–55, (2) 48–54, (3) 75–85, (4) 44–58, (5) 27–37, (6) 24–34, (7) 27–31, (8) 46–51.

Leg I: coxa 122, femur + trochanter 290, tibia 211, tarsus 126, claw 34μ.

Anal lobes approximately 165μ long.

This insect is common throughout South Africa on *Mesembryanthemum* spp., especially *M. edule*, Linn. It becomes so numerous in some seasons that it kills patches of this plant when grown in parks, etc. This was the case at the Eastern Sports Grounds, Pretoria, in November 1914.

The ♂♂ emerged from the next generation about Christmas 1914 and the following particulars are given from fresh material obtained at that time :—

Male test, transparent, white, glassy, about 1·5 mm. long, margins depressed, central plate raised, slightly keeled.

Body, legs and antennae dark brown. Wings broadly rounded, iridescent, dorsal sclerites and eyes shiny black. Two caudal waxy filaments, white, as in *Pseudococcus*, length equal to head + body without antennae.

Length of head + body 1·17 mm. (without genital spike); length of wing 1·0 mm.; width of wing 0·5 mm.; length of antenna 0·84 mm.; length of genital spike 0·27 mm.; length of caudal setae 1·0 mm.

Antennae 10-jointed, the segments measuring: (1) 34, (2) 48, (3) 51, (4) 180, (5) 112, (6) 105, (7) 85, (8) 68, (9) 61, (10) 74μ.

Habitat: On *Mesembryanthemum* spp., chiefly *M. edule*, Linn., throughout the Union.

Collection No: 78.

218. **Pulvinaria psidii,** Mask.

Pulvinaria psidii, Mask., N.Z. Trans. xxv, p. 223, 1892.

Adult ♀ pale transparent yellow with irregular black markings; 2 mm. long and 1·7 mm. broad. The ovisac is white, as wide as the body, always *flat*, attaining twice the length of the body. Ova pale yellow.

Larvae pale yellow, hatching when received, 16th November 1914.

Adult ♀ flatly convex with slightly raised median keel. Anal plates pale brown.

Antennae 8-jointed; range in μ: (1) 24–34, (2) 37–44, (3) 51–58, (4) 27–34, (5) 27–34, (6) 20–24, (7) 14–20, (8) 41–44.

Leg I: coxa 68, femur + trochanter 190, tibia 145, tarsus 85, claw 27μ.

Anal plate about 130μ long. Margin with a row of thin spines about 34μ long, tips divided but not dilated. These spines are set much closer together on the anterior part of the body. Integument clear, with a few simple glands with short

spines and a few long hairs near the insertion of the antennae. Stigmatic spines; laterals short, conical; median longer (51μ).

Habitat: On guava, Botanic Gardens, Durban; collected by A. Kelly, November 1914.

Collection No.: 81.

Genus **Ceronema,** Mask.

Maskell's original diagnosis of this genus, as given in the Transactions of the New Zealand Institute, p. 55, 1894, is as follows:—

"Female insects in the adult stage covered wholly or partially by tests of threads more or less closely woven, neither glassy nor felted, never forming homogeneous plates. No fringe. Form of insect Lecanid, with normal cleft and lobes.

"Larva Lecanid, showing cleft and lobes.

"Male pupa covered by a glassy test of normal Lecanid form, composed of plates more or less homogeneous."

219. **Ceronema mobilis,** sp. n.

Adult ♀ about 3 mm. long, broad oval in outline, flat, with the dorsum almost entirely covered with long, white, waxy filaments. Around the margin the filaments are long and coarse, but those on the dorsum are short and fine and ± curly and densely matted and appear almost felted. The colour of the insect, beneath the secretion, is caramel brown.

When cleared and mounted the body is broad oval; integument thin and transparent with numerous scattered, small, simple gland openings. Margin very closely set with a very short fringe of marginal spines, which are only about 20μ long, thin, linear, two or three, usually two, arising from the same pore; they are unusually close together, averaging about 14μ apart. Stigmatic clefts shallow, but distinct because of their chitinised sides; each cleft with two or three curved, blunt processes which are about as long as the marginal spines.

Antennae 7-jointed; range in μ: (1) 27–37, (2) 41–51, (3) 34-54, (4) 68–78, (5) 27–31, (6) 17–27, (7) 41–44. Joints 2 and 4 each with two long setae, 5 with one, 6 with two and 7 with eight.

Leg I: coxa 75, femur + trochanter 187, tibia 105, tarsus 68, claw 24μ.

Anal plate about 140μ long with 1 apical and 3 subapical spines.

Habitat: On leaves of common native bush (*Celastrus cordata*, E.M.) (Celastrineae); collected by C. Fuller, Illovo River, Natal, August 1916.

Collection No.: 97.

The adult ♀ moves about quite readily. A number of mature specimens were put on one side when received with a view to photographing them, but next day, when the leaves had slightly dried, the insects had all crawled off and so disarranged the waxy filaments.

Genus **Lichtensia,** Sign.

Adult ♀ oval or suboval, like a *Pulvinaria*, except that the secretionary sac covers the whole body with the exception of the cephalic end, which is usually more or less exposed. Antennae 8-jointed.

220. **Lichtensia asparagi,** sp. n.

Female ovisac about 4·5 mm. long, elongate, narrow and very convex, sordid white in colour, thin but dense, with the anterior extremity open, exposing the front portion of the dry female.

Male puparium moderately large, elongate, very convex, with perpendicular sides, thin, semi-opaque, dorsum flatly rounded, entirely without median plate. There is a faint indication of sublateral lines, otherwise the surface is uniformly stippled.

Adult ♀, mounted, broad oval, about 4 mm. long, with the two extremities about equally rounded ; anterior extremity not produced.

The integument appears remarkably free from conspicuous glands or hairs. Margin with a single scattered row of short sharp curved spines. Stigmatic spines stout, somewhat curved, with rounded ends.

Antennae 8-jointed, in one antenna examined 9-jointed, with the following range in μ: (1) 35–48, (2) 57–60, (3) 68-78, (4) 51-71, (5) 40–61, (6) 30–37, (7) 25–34, (8) 30–38.

Leg I : coxa 88, femur + trochanter 228, tibia 190, tarsus 102, claw 24μ.

Anal plate about 185μ long, with longitudinal folds.

Habitat : On *Asparagus capensis*, L. (Liliaceae), Eastern Cape Province.

Collection No. : 131.

Genus **Filippia,** Targ.

Female flat, oval, legs and antennae normal. Side of body and dorsum with numerous tubular glands. Female, at maturity, entirely enclosed in a flat felted sac which, after oviposition, serves as an ovisac.

221. **Filippia chilianthi,** sp. n.

Adult ♀ entirely covered with a dense, closely felted layer of white secretion, about 6 mm. long and 3 mm. broad, ± regularly oval, with the dorsum moderately convex. This secretionary layer is secreted slowly from all the upper parts of the body, the glands concerned being scattered. This is not the case in the Pseudococcinae, in which the ovisac is formed by secretionary glands in the posterior and marginal portion of the body only. Little or no secretion appears on the ventral surface, so that the leaf or twig forms the floor of the sac ; the marginal secretion becomes attached and entirely encloses the ♀. As oviposition proceeds the body shrinks away from the posterior end of the sac which becomes almost filled with ova. At death the dry shrivelled body of the ♀ occupies a small portion at the anterior end.

Prior to secreting the ovisac the ♀ is from 4 to 5 mm. long, and rather more than half as wide. The sides are almost parallel for more than half the length of the body, the posterior end appearing broadly rounded, and the anterior end more pointed. In colour it appears greyish brown with a lighter median, flatly rounded, keel. When seen under a hand-lens, however, it is noticed that the ground-colour of the body is yellowish, and semi-transparent, speckled with black. The anal cleft is short, with the sides closely adjacent. The anal plates are small and brown. The lower surface is slightly concave, greasy-yellowish in colour, the black speckling of the dorsum only showing faintly through at the extreme margins. The stigmatic bands are represented by two short faint white lines on each side.

At a younger stage—when about 2·5 mm. long—the body is red-brown, rugose at the edges, with the median keel not prominent but smoother than the remainder of the body.

The antennae are 8-jointed; range in μ: (1) 31–45, (2) 50–62 (3) 95–108, (4) 54–65, (5) 32–44, (6) 27–34, (7) 27–34, (8) 31–37.

Leg I: coxa 102, femur + trochanter 245, tibia 165, tarsus 85, claw 20μ.

Tarsal digitules moderately long (70μ), slender hairs with their distal ends slightly clubbed. Lower digitules short, broad. Marginal spines short (27μ), truncate. Anal plate about 155μ long. Stigmatic cleft with three comparatively slender spines, laterals about 34μ, median similar but longer (51μ).

Male puparium about 2 mm. long and 1 mm. wide, dark red when containing the insect; white and glassy when empty. The divisions of the test are very prominent, opaque white; the remainder being ± wrinkled and almost hyaline.

Adult ♂♂ were emerging in large numbers when the material was received, 5th April 1916.

Copulation was observed in a number of cases, the ♀ in each case measuring about 4 mm. in length. The body of the male was curved downward admitting the sheath into the cleft of the ♀. During this process the two long waxy filaments of the ♂ stood erect.

The adult ♂ is about 1·0 mm. long, rich red-brown in colour, with two long waxy caudal filaments about half as long again as the head and body combined, without the antennae. The body, legs, and antennae are all red-brown. The head is slightly darker. The scutellum is polished at the edges, with a sunken, matt, central patch. The wings are hyaline, matt, extremely iridescent, with a strong sub-costal, cochineal red band.

When mounted, the following measurements may be taken as an average :—

Head and body, without antennae	1·3 mm.
Antennae	0·847 mm.
Genital spike	0·27 mm.
Wings: length 1·2 mm., width	0·6 mm.
Caudal filaments	2·0 mm.

Habitat: On a native shrub; collected by C. Fuller, Illovo River, Natal, April 1916. On leaves of *Chilianthus oleaceus*, Burch (Loganiaceae), Bloemfontein, O. F. S.; collected by J. C. Faure, April 1916.

Collection Nos.: 127 and 128.

This insect, with the ovisac completed, is similar in appearance to *F. oleae* (Costa) but, according to Signoret's description of that species, the adult has 6-jointed antennae.

222. **Filippia carissae,** sp. n. (Plate i, fig. 236).

This species differs from *F. africana* in the following respects :—

The ovisac is a little larger and generally less compact; often split around the edges (fig. 236). The antennae are more variable, 7 or 8-jointed, range in μ :—

(*a*) 8-jointed: (1) 41–54, (2) 51–54, (3) 102–119, (4) 68, (5) 37–44, (6) 34, (7) 24–27, (8) 34–37; (*b*) a specimen with 7-jointed antennae gave the following measurements :—

i.	54	68	105	122	34	27	41
ii.	41	68	109	68	51	37	68

Leg I: coxa 95, femur + trochanter 240, tibia 204, tarsus 88, claw 20μ.

Anal plate 176μ, rather elongate, with one or two long spines at apex. Margin with a single row of ± plate-like spines, narrow at the base and gradually broadening at the distal ends. Stigmatic clefts somewhat sunken, with three spurs of moderate length.

Habitat: On leaves of *Carissa grandiflora*, A. DC. (Apocynaceae), Natal Coast; common.

Collection No.: 129.

Genus **Conofilippia,** nov.

Female Lecaniid, flat, with well developed legs and antennae; dorsum with numerous sharp spines; margin with slender spines and stigmatic cleft similar to *Lecanium*. At maturity the insect is entirely enclosed in a dense felted sac, which is elevated in the form of a high cowl. Antennae 7-jointed.

Type, *C. subterranea*, sp. n.

223. **Conofilippia subterranea,** sp. n. (Plate iii, fig. 245).

Adult ♀♀ enclosed in conical felted tests on the roots of a native shrub. Test about 6 mm. long, 5 mm. broad and 5 mm. high (figs. 245*a*, *b*).

Adult ♀ flat, about 5·5 mm. long, 4 mm. wide, smooth, glossy, pink to red in colour, brown and wrinkled when dry, on a thick mat of dense powdery material (the floor of the test) which is buff to yellow-brown in colour and dusted with white wax beneath the insect.

In one or two cases the top of the test shows a circular orifice, but this does not appear to be normal and looks as though it had been made for the exit of some Hymenopterous parasite.

Largest ♀, when mounted, about 6 mm. long, and 4·2 mm. wide. Integument clear, with a number of simple glands which are particularly abundant near the margin, and with numerous short (17μ) sharp spines. The margin is thickly set with a compound series of slender spines about 24μ long, which are somewhat curved near their tips. Stigmatic clefts with three blunt spurs, laterals about 27μ, median about 37μ.

Antennae 7-jointed; range in μ: (1) 35–40, (2) 25–34, (3) 40–47, (4) 37–42, (5) 34–44, (6) 17–30, (7) 37–51. In one case joints 6 and 7 were united, forming a segment 64μ long.

Leg I: coxa 102, femur + trochanter 220, tibia 170, tarsus 100, claw 40μ. The junction of the tibia and tarsus is swollen and suddenly narrows towards the distal half of the tarsus.

The anal lobes are rounded, about 230μ long.

Habitat: On roots of native shrub with red stems; collected at De Wildt, Pretoria District, Transvaal, by Claude Fuller, May 1915. The drawings (figs. 245-b) were kindly made from living material by the collector.

Collection No.: 137.

Genus **Ceroplastes,** Gray.

Adult ♀ completely enveloped in a more or less dense covering of wax; no marginal fringe or radiating processes. Sometimes the waxy covering exhibits a variety of arrangement in the form of definite plates or plaques. In other species the covering is uniform in texture and is then most often soft, and contains a large percentage of watery fluid. On removing the wax a caudal prominence is generally visible. Legs and antennae present, well developed.

224. **Ceroplastes bipartitus,** Newst.

Ceroplastes bipartitus, Newst., Bull. Ent. Res. viii, 1, p. 25, 1917.

"Female test. Colour of dried specimens very like pale dirty beeswax. In the young adults the test is broadly oval, somewhat hemispherical and divided into nine plates: three bilateral, one cephalic, one anal and one dorsal, the last-named with a conspicuous dark brown or blackish oval spot, with a central elongated patch of pure white wax; the nuclear spots to the lateral plates are smaller and generally much less conspicuous than the dorsal one. Margin over the stigmatic areas with a pair of laterally compressed and somewhat disc-shaped extensions, each extension carrying on its edge a narrow strip of opaque white wax, the tip of which sometimes reaches the dark nuclear spot of the lateral thoracic plate. In very old examples the test has increased in thickness considerably, but this has been so much damaged in transit as to render it useless for descriptive purposes; however, one can trace the curious marginal extensions, which are somewhat like a narrow-waisted and distorted bobbin, or the toy used in the once popular game 'diabolo.' Average length of young adults, 3 mm.; height 1·6–2 mm.; average length of old adults, 6 mm.; height doubtful.

"Female adult. Denuded of wax, hemispherical; caudal process very long, varying in length from one-half to a little less than one-half the length of the remaining portion of the insect. Submarginal tubercles small, but generally clearly defined; one cephalic and three bilateral, the two over the stigmata slightly more pronounced than the rest. When examined under a high power lens, by transmitted light, these tubercles are seen to be traversed by clear cell-like tracts forming an irregular reticulated pattern. It is reasonable to assume, therefore, that these may be the special set of glands which secrete the nuclear spots in the centre of the plates in the test. Derm relatively thin, but strongly chitinised. Pores minute, separated over a large portion of the dorsum by slightly varying distances equalling the length of one of the short segments of the antennae or two of them together. Stigmatic clefts relatively shallow, but very clearly defined; spines short, obconical, those at the extreme margin very minute and stud-like. Marginal spines or hairs not traceable. Antennae of six segments, the 3rd longer than the last three together. Legs normal. Length of denuded female, inclusive of the caudal process, 4·5–4·6 mm.; length of caudal process, 1·3–1·5 mm.

" Male puparium. Consisting of two distinct parts ; the lower half boat-shaped, and of a glassy vesicular texture, as in those typical of the genus *Lecanium* ; the upper portion opaque, low, convex, and of a dirty beeswax colour, with nine narrowly rectangular, submarginal patches of snow-white secretion. Anal cleft apparently obsolete. On the emergence of the male the whole of the upper portion falls away, leaving the ventral half attached to the food-plant. The line of cleavage between the upper and lower portion is clearly defined in those puparia from which the imprisoned male has not escaped. Length 1·6 mm.

" South Africa, 1914 (de Charmoy)." (Newstead.)

This species is apparently not represented in the collection of this Division.

225. **Ceroplastes candela,** Ckll. & King.

Ceroplastes candela, Ckll. & King, The Entom. xxxv, p. 113, 1902.

" ♀. Long $2\frac{2}{3}$, lat. $3\frac{1}{2}$, alt. $4\frac{1}{2}$; dark red-brown, elevated, with vertical sides. Caudal horn a prominent stout spine, hardly $\frac{1}{2}$ mm. long, placed nearer the top of the scale than the base. Dorsum smooth and shining, with only a very small central raised line. Sides of insects with vertical stripes of dense secretion ; no wax, except that composing these stripes, between the insects, which are densely crowded together, their vertical sides contiguous. They rest on a thin substratum of wax, and are covered above with yellowish-white wax, about 1 mm. thick. The outlines of the insects are vaguely marked on the surface of the covering wax by a brownish stain. The wax, with the insects beneath, surrounds the twig as the wax does the wick of a candle; the whole mass is about 20 mm. diameter, that of the twig being about 5 mm.

" Mr. King found the antennae to measure thus in μ :—

Joints	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Length	56	68	56	60	28	32	40
Breadth.. ..	64	48	40	32	28	28	24

" Found by Mr. Fuller at Richmond, Natal. The nearest ally is an undescribed species from Paraguay, collected by Professor Bruner." (Ckll. & King).

This species is not represented in the collection.

226. **Ceroplastes combreti,** sp. n.

Test of ♀ about 3 mm. long, broad and high, conical, with the anterior side a little more precipitous than the posterior, which is somewhat excavate above. There are no plaques, but the whole body of wax is arranged in ± distinct columns, three on each side. The apex is blunt, bearing an opaque white ridge surrounded by six opaque white spots—the tops of the columns. Between the two most prominent lateral ridges are the distinct white stigmatic bands which extend from the base to the crown. The colour, when fresh, is bright rose-red with darker transverse marks.

The antennae are 8-jointed ; range in μ : (1) 37–44, (2) 56–61, (3) 34–48, (4) 27, (5) 37–41, (6) 20–24, (7) 17–24, (8) 37–41.

Leg I : coxa 75, femur + trochanter 180, tibia 129, tarsus 85, claw 20μ.

Anal plates ± semicircular, about 160μ long and 85μ broad. The derm is thin and transparent, with numerous small, scattered, simple glands, from some of which short, tubular projections arise. Stigmatic clefts with large numbers of very small, roundly conical, thimble-shaped spines.

The distinct, long, opaque white lines, the reddish colour, soft wax, etc., suggest *quadrilineatus* of Newstead, but this latter species has 6-jointed antennae and is obviously quite distinct by other characters of the test.

Habitat: On stems of *Combretum* sp., De Wildt, Pretoria District; collected by Claude Fuller, July 1918.

Collection No.: 317.

227. **Ceroplastes destructor,** Newst.

Ceroplastes ceriferus (Anderson) Newstead, Bull. Ent. Res. i, pp. 66, 195, 1910.

Ceroplastes destructor, Bull. Ent. Res. viii, p. 26, 1917.

" Female test. White, creamy white or dirty white; exceedingly soft and containing an excess of moisture. Form irregular, with large but ill-defined gibbose protuberances; sides usually with two narrow opaque lines of secretion from the stigmatic clefts. No trace of lateral plates. Length, 4–8 mm.

" Female, adult. More or less hemispherical, with the sides often slightly compressed; caudal process long; integument castaneous and highly chitinised, smooth and shining, and without fovea or lateral tubercles. Antennae of six segments, the 3rd being as long as the 4th, 5th, and 6th together; the last three segments with stiff and bluntly pointed, spinose hairs. Legs small; hind femora very short and often distinctly incrassate; hind tarsi equal in length to the tibiae, or sometimes slightly longer. Claw very short; lower digitules very long and stout; upper digitules normal. Stigmatic clefts well defined, but relatively small; stigmatic spines very small and pointed, bases not constricted; basal attachment (disc) very large. Caudal process (after maceration) transparent and somewhat flexible; sides with an irregular double row of short spinose hairs, and in addition to these there are two pairs of longer hairs (one pair of which is twice the length of the others) slightly ventral to the row of short ones and towards the distal extremity. Anal lobes short and highly chitinised. Dorsal pores very small, rather widely separated. Ventral integument opposite the caudal process, with rather extensive groups of circular pores, many of which, in well cleared specimens, are linked together with lines of dark chitin. Length 4–7 mm." (Newstead.)

Habitat: On custard apple and avocado, Nelspruit, Transvaal; collected by D. Gunn, September 1915 (Coll. No. 93). On syringa (*Melia azedarach*), Bechuanaland, October 1918 (*Coll. No.* 336).

Collection Nos.: 93 and 336.

228. **Ceroplastes egbarum,** Ckll.

Ceroplastes egbarum, Ckll. The Entom. xxxii, p. 127, 1899.

Ceroplastes cristatus, Green, Ann. Mag. N.H. (7) iv, p. 190, 1899.

Professor Cockerell's description is as follows:—

" Waxy female scales often crowded on the twigs, two or more coalescing; about 11 mm. long, 10 broad, and 6 high, the wax extremely thick, not at all divided into plates, snow-white, here and there with a suffused pinkish stain.

" ♀. Denuded of wax 5½ 7 mm. long, 4 broad, 2½–3 high, very dark, with a dorsal hump but no lateral humps ; anal horn a mere mammiform prominence. Boiled in caustic soda the denuded females give a purple colour, which on dilution with water appears pink, and soon forms a flocculent pink precipitate. On adding nitric acid a flocculent white precipitate appears, but the pink precipitate is not altered. Skin after boiling remains yellowish brown, chitinous, with scattered minute gland-dots. Stigmatic areas with numerous crowded gland-spots, and many short and rather thick simple spines, but no capitate spines. Legs dark brown, the parts measuring thus in μ : Coxa, 120 : femur with trochanter, 180 : tibia, 128 ; tarsus with claw, 96 to 114. Tarsal digitules 60μ, slender, with a small knob. Claw digitules with very large round knobs, extending about 15μ beyond tip of claw. Antennae apparently only 6-segmented, but the segmentation towards the end very obscure. The segments measure in μ : (1) 45 ; (2) 60-69 ; (3) 66-78 ; (4) 51 ; (5) 69 ; (6) 72. Segment 5 has a deep notch which makes it look as if divided into two.

" Young larvae under female about 430μ long and 230 broad, tinged with a warm reddish colour. Male scales small, elongate, and glassy."

In the description of *C. africanum* var. *cristatus* Green states that specimens from Natal differ from *africanum* (i.e., *mimosae*) only in the presence of a small dorsal crest corresponding to the position of the central scar. They were, however, larger, being 12 mm. in diameter. This would seem to indicate, moreover, that the antennae may be 6, 7, or 8–jointed.

Habitat : On *Acacia*, Natal.

Collection No. : 87.

229. **Ceroplastes egbarum fulleri,** T. & W. Ckll.

Ceroplastes egbarum subsp. *fulleri*, T. & W. Ckll., The Entom. xxxv, p. 113, 1902.

Adult ♀, with waxy covering about 14 mm. long, 12·5 mm. wide and 7 mm. high. Waxy covering regularly domed with a slight depression in centre. Margins widely crenulate, with usually two conical deflected waxy masses which clasp the stem. Stigmatic cleft waxy appendages conspicuous, snow-white, long and slender. There are two of these on each side, usually 3 to 4·5 mm. long, about 1 mm. thick at attachment to waxy covering, but gradually tapering to their extremities. They usually lie closely pressed to the stem of the host plant. The colour of the waxy covering is whitish to coral, pink, with distinct brown patches on the intermediate area and lighter zones around the dome.

Female, denuded of wax, 7 mm. long, 5·5 mm. broad and 4 mm. high. Colour coral pink, more yellowish than the darker coloured wax. The extreme frontal margin, the stigmatic clefts and the caudal projection are dark castaneous and shiny. In older specimens, after oviposition, the integument becomes brown.

The venter is flat or concave with the median zone sunken and segmented. The 4 white stigmatic bands extend inwards to this sunken area. The lateral margins are slightly excavate, the upper edge of the excavation being formed by seven depressed conical projections from the intermediate area. The anterior of these extends forward until nearly level with the front edge of the rounded anterior lobe.

The three lateral projections of each side are shorter and more bluntly pointed. The depressed area which separates the central cone from the intermediate area is coarsely punctate. The central cone is regular, elongate, oval at the base and roundly pointed at the apex. There is no sunken area in the centre.

The caudal projection is exceptionally short, bluntly conical, projecting at an angle of about 45° with the ventral surface.

Antennae 8-jointed; range in μ: (1) 44–51, (2) 48. (3) 58–68, (4) 34–37, (5) 27–34, (6) 20–24, (7) 20–24, (8) 37–48.

Integument clear, hyaline, except for the extreme margin, marginal expansions and caudal prominence, which are densely chitinised. The anterior margin is broadly rounded with a distinct parallel-sided chitinous band. Lateral margins with two almost circular expansions on each side. These are much larger than those found in *mimosae*.

Habitat: On "monkey rope," Natal coast, Umbilo and Equeefa Rivers.
Collection No.: 88a.

230. **Ceroplastes eucleae,** sp. n. (Plate ii, fig. 239).

Adult ♀ tests sometimes single on stem, often aggregated in dense masses. Test of adult ♀ about 6 mm. long, 5 mm. wide and 5·5 mm. high, without plaques but with the lower portion forming a wrinkled fold at the base of a highly conical dome. The colour is a delicate green, when alive, with the stigmatic bands conspicuous (fig. 239); when dry, it is semi-transparent, greenish yellow, with two white thin streaks on each side just above the stigmatic clefts. The central dome is pointed, without any central pit or depression, and is distinctly separated from the lower portion of the test by a groove. There is no indication of a caudal prominence on the test.

Female, denuded of wax, smooth, regularly domed, without caudal prominence, chitin pale brown and moderately thin; portion surrounding the anal plates deep castaneous. Caudal prominence rudimentary, indicated by deeper coloured chitin. When cleared, the derm is moderately chitinous. That of the dorsum is very finely rugose with very scattered small, transparent spots. The denser, marginal folds have in addition a few larger holes.

Antennae 6-jointed; range in μ: (1) 24–30, (2) 37–40, (3) 91, (4) 17–21, (5) 24–27, (6) 40.

The legs are moderately developed, normal.

Stigmatic clefts with a series of short, conical, thimble-shaped spines, which extend in a single row for some distance along the margin on either side of the cleft, where they compose a double row. About the middle of the group is a large spine, about twice as large as the others. Within the double row is a collection of small simple glands like the circumgenital glands of the Diaspinae.

Habitat: On stems of several native shrubs, including *Euclea* sp., *Ochna* sp. ?, *Pavetta* sp. ?, etc., Pretoria; collected by Miss E. Impey, January 1915.

Collection Nos.: 90 and 342.

231. **Ceroplastes longicauda,** sp. n.

Adult ♀ covered with a very thick layer of soft, white wax forming a test like a large *ceriferus* specimen, i.e., a little more elevated than *egbarum*. Largest specimen seen measured 18 mm. long, 11 mm. wide and 12 mm. high; marginal area prominent, forming a wide fold at the base of the central dome. The waxy appendages from the stigmatic clefts only project slightly from the main mass of the fold.

Adult ♀, denuded of wax, bright brown in colour, about 5 mm. long without caudal process, which alone measures 3·5 mm. The body is ± star-shaped with three short, lateral pointed spurs and one anterior. These are sharper and more prominent than those of *ceriferus*. The dorsum is very convex, rising with straight sides to an acute point. The caudal process is exceedingly long, two thirds the length of body, piceous, slightly tapering, and extends in a horizontal direction, i.e., flat along the twig.

Cleared and mounted, the insect is remarkable for the broad oval, thin, transparent body with a very long dense black tail. The integument is uniformly hyaline, without chitinous marginal discs such as those found in *fulleri*, etc. In stained material the integument of the dorsum illustrates a strange segmentation ± in plates, 5 elongate transverse median ones and shorter laterals.

The antennae are 7 or 8-jointed, e.g., (1) 40, (2) 37, (3) 40, (4) 47, (5) 68, (6) 30, (7) 27, (8) 37μ; or (1) 23, (2) 34, (3) 40, (4) 88 (with pseudarticulation), (5) 27, (6) 27, (7) 37μ.

Stigmatic cleft thin, hyaline, with a patch of scattered, short, thimble-shaped spines and, within this, a large group of simple glands similar to the circumgenital glands of the DIASPINAE.

Legs comparatively short, otherwise normal.

Habitat: On stems of native shrub; collected by C. Fuller, Natal Coast, July 1915.

Collection No.: 334.

This species is very similar in many respects to *C. ceriferus* but may be readily separated by the larger size of the adult ♀ test, the comparatively longer caudal process and the 7 or 8-jointed antennae. *C. ceriferus* has antennae 5 or 6-jointed, usually 6.

232. **Ceroplastes mimosae,** Sign. (Plate ii, fig. 241).

Ceroplastes mimosae, Sign., Ann. Soc. Ent. Fr. (5) ii, p. 46, 1872.

Ceroplastes africanus, Green, Ann. Mag. N. H. (7) iv, p. 188, 1899.

"Insects crowded on the stems of the plant, so much so that the waxy covering of adjacent individuals becomes more or less confluent and the normal form of the test is difficult to determine. The tests appear as rounded masses of cream-coloured wax, each with a more or less distinct nipple-like prominence at the apex bearing a small spot of whiter substance.

" The usual opaque white bands from the spiracular regions are present, but very inconspicuous, scarcely extending beyond the margin. In some specimens a series

of impressed arches on the sides of the test marks the position of the marginal plates. The waxy coating being thinner on the impressed parts, the arches appear darker, the colour of the body of the insect showing through the covering-matter. An isolated test averages 7·75 mm. long, 6·50 mm. broad, 5·75 mm. high.

" Female, denuded of wax, reddish brown to dark brown, the whole surface strongly chitinised ; irregularly globose ; apex often with an oblong scar corresponding with the position of the early larval pellicle, but which becomes almost obliterated in the oldest examples. In the early adult the median is separated from the marginal area by a more or less distinct furrow, which is particularly marked where it meets the anal tubercle. In the older examples only this hinder part of the furrow remains. Cephalic area constricted off from the globose body, forming a trowel-shaped projection in front. Spiracular clefts deeply indented, thickly set with small conical spines, not constricted at the base. Marginal hairs very small, few and inconspicuous. Anal scales minute, inner edge straight, base and outer edge together forming a semicircle. Anal tubercle blackish, directed upwards. Derm with numerous glandular pores, which are more distinct on the darker marginal area. Antennae with either 7 or 8-joints. It is difficult to say which is the normal number, as the two varieties are about equally represented in the series under examination. With the 8-jointed form the formula runs :—3, (1, 2), 8, 4, 5, (6, 7). When there are seven joints only the formula is 3, (1, 2, 4), 7, (5, 6). In this latter case there is a tendency for the fourth joint to separate into two, and there is always a more or less distinct false joint in the terminal segment. Legs well developed ; tarsus more than half length of tibia. Foot with 4 digitules, the unguals broadly spatulate, the tarsals fine knobbed hairs.

" Length of fully developed female 5·50 mm., breadth 5·0 mm., height 4·25 mm.

" The male insect is unknown in any stage." (Green.)

The material I have examined has a characteristic odour and has uniformly 8-jointed antennae, with the following range in μ : (1) 27–34, (2) 41–48, (3) 58–68, (4) 27–41, (5) 17–37, (6) 17–24, (7) 20–24, (8) 34–37.

Habitat : On *Acacia karroo*, Cape Colony ; common but local.

Collection No. : 85.

233. **Ceroplastes myricae** (Linn.).

Coccus myricae, Linn., Syst. Nat. Ed. xii, i, p. 741, 1766.

Columnea myricae, Targ., Catalogue, p. 35, 1869.

Ceroplastes myricae, Sign., Ann. Soc. Ent. Fr. (5) ii, p. 39, 1872.

" Habitat ad Cap. B. Spei, in Myrica quercifolia.

" Magnitudo pisi minoris, semi-ovatus secundum perpendiculum, pallide incarnatus, vertice obtuse acuminatus cum poro tenuissimo, postice supra marginem etiam porus est, margo cartilagineus, crassior albus, utrinque circiter septem torutis protuberans.

" Dans Olivier, Encyclopédie, VI. 96, 8, nous trouvons une description presque identique : la femelle est presque de la grandeur d'un petit pois, le corps est d'une couleur rouge pale et de forme demi-ovale, le vertex est elevé et percé d'un petit point, tout le bord est cartilagineux, épais, blanchâtre, marqué de chaque côté de petits cordons élevés.

"Ce sont ces sept cordons élevés qui, spécifiant bien l'espèce, nous empêchent de l'attribuer aux nombreux individus que nous possédons et decrivons sous le nom de *C. Vinsonii.*" (Sign.)

Myrica quercifolia, Linn. (Myricaceae) is a near relative of the waxberry plant which is common on the Cape Flats. Mr. C. W. Mally, the Entomologist for the Cape Province, has recently kindly examined a large number of plants in an endeavour to re-discover this species of *Ceroplastes*, but as yet without success.

234. **Ceroplastes pallidus,** sp. n.

Test of adult ♀ to 8·5 mm. long, 6 mm. broad and 4·5 mm. high; very much like a large *C. rusci* in form, with 8 lateral plaques and median dome. The lateral plaques, however, are without "nuclei" and are a little more perpendicular. In old specimens the waxy covering is pale, semi-transparent, yellowish, or having an indistinct greenish tint. The central dome is moderately elevated, somewhat tapering, slightly glossy, with longitudinal and concentric striae. The central "nucleus" is elongate, glossy and a little darker in colour. Stigmatic clefts indicated by small white dots.

When cleared and mounted the integument is all thin and hyaline, without anterior or marginal thickenings and with only a small area surrounding the anal lobes chitinised.

Stigmatic clefts shallow, not chitinised, with short, conical, pointed spines which are in a single row for a short distance on each side, but broaden out to form a small triangular patch opposite the spiracle; at no point, however, are there more than 5 rows. Within this series is a compact group of simple glands like the circumgenital glands of the DIASPINAE and also a few smaller glands and short simple hairs. The remainder of the margin has a scattered, single row of short, slender, sharply pointed spines.

The antennae are 8-jointed; range in μ: (1) 37–44, (2) 37–47, (3) 44–52, (4) 34–44, (5) 51–56, (6) 27–32, (7) 27–34, (8) 35–47.

Legs well developed, normal; tibia long, with a constriction at about the middle.

The caudal tubercle is comparatively small, a mere plate with the chitin appearing $\pm$ streaky and somewhat perforate.

Habitat: On fig, Church Square, Pretoria.

Collection No.: 102.

235. **Ceroplastes quadrilineatus,** Newst., var. **simplex,** nov.

Adult ♀♀ clustered in large masses on the twigs of the host plant. ♀ test about 5 mm. long, 4·5 mm. broad and 3 mm. high, very dark in colour, almost black, with the thinner parts of the wax appearing reddish. Marginal fold corrugated, lighter and more transparent in colour than the central dome, with two very distinct lines of opaque white on each side. The central portion is comparatively flat and truncate, separated from the marginal fold by a deep furrow in dry material, with the apex hollowed into a shallow cup containing an opaque white ridge. The ridge of this cup-like depression is not regular but consists of an anterior transverse ridge and two posterior lateral spurs, and the floor usually slopes gently forward. The

anal opening to the test is surrounded by a distinct circular ring which is itself sunken in a deep depression with broadly rounded sides. In dry specimens the whole waxy material is roughened, hard and very brittle. The pair of larger divergent pyriform bodies referred to in the description of *quadrilineatus* are not present.

When cleared of the waxy covering the insect is of a characteristic form, with the dorsum uniformly rounded and smooth and the marginal area produced in a series of broadly rounded bead-like lobes. The caudal prominence is extremely rudimentary, appearing as a flatly rounded hump, black in contrast with the deep red brown of the remainder of the insect. The integument, when cleared, is dense and is pitted like that of many species of *Saissetia*. The stigmatic spines are in an elongate row around the shallow cleft, the series becoming double in the centre.

The antennae are 6-jointed, three being very long and variable, e.g. :—(1) 27, (2) 37–40, (3) 88–119, (4) 20, (5) 27, (6) 44–51μ.

Legs long, normal. Chitin of caudal protuberance appears as though bossed with a honey-comb pattern.

Habitat : On stems of *Rhus* sp. (probably *R. viminalis*), Victoria West, C.P.; collected by Mr. van Heerden, October 1915.

Collection No. : 346.

236. **Ceroplastes rusci** (Linn.)

Coccus rusci, Linn., Syst. Nat. Ed. x, i, p. 456, 1758.

Coccus caricae, Bern., Mem. Acad. Marseille, p. 89, 1773.

Coccus artemisiae, Rossi, Mant. Ins. ii, pp. 56, 514, 1794.

Calypticus radiatus, Costa, Faun. Reg. Nap. Cocc., p. 12, 1835.

Calypticus testudineus, Costa, Faun. Reg. Nap. Cocc., p. 12, 1835.

Calypticus hydatis, Costa, Faun. Reg. Nap. Cocc., p. 14, 1835.

Columnea testudinata, Targ., Atti dei Georgofili, n.s. xiii, p. 31, 1866.

Coccus hydatis, Targ., Studii sul. Cocc., p. 12, 1857.

Columnea testudiniformis, Targ., Studii sul. Cocc., pp. 8, 11, 12, 1867.

Chermes caricae, Bdv., Ent. Hort., p. 320, 1867.

Ceroplastes rusci, Sign., Ann. Soc. Ent. Fr. (5) ii, p. 35, 1872.

Lecanium artemisiae, Sign., Ann. Soc. Ent. Fr. (5) ii, p. 37, 1872.

Adult ♀. Test about 7·5 mm. long, 5·2 mm. broad and 5 mm. high, regularly domed, rounded in front, rather excavate behind. Colour greasy white, suffused with purplish red. Dorsal dome and margins of plaques lined with greenish grey lines ; anal pore and middles of plaques of same colour. Stigmatic bands, 2 on each side, pure white, broad at stem and tapering inwards. Middle of dorsum with a depression in which there is an elongate, glossy white prominence similar to those in centres of plaques, but longer.

Antennae 6-jointed ; range in μ : (1) 34–40, (2) 37–40, (3) 114–120, (4) 17–24, (5) 20–27, (6) 44–57.

Leg II : coxa 102 ; femur + trochanter 170 ; tibia 120 ; tarsus 85 ; claw 20μ. Margin of sides of body with a single row of small thimble-like spines ; amongst these are mixed a few simple spines. Stigmatic clefts very shallow, not chitinised,

with a few additional spines like those of the marginal series and a small group of simple glands like the circumgenital glands of the DIASPINAE. Anal plate heavily chitinised, with scattered perforations.

Habitat: On stems of quince, Stellenbosch, C.P.; collected by F. W. Pettey, July 1916.

Collection No.: 91.

237. **Ceroplastes tachardiaformis,** sp. n.

Adult ♀ tests aggregated in huge masses on stems of the host-plant, often completely covering the stems for a distance of several inches.

♀ test *Tachardia*-like, globular, slightly flattened above, hard, thin, brittle, almost transparent resinous brown, due to the colour of the insect within; without protuberances but with a slight apical depression containing the opaque white larval exuvia.

Adult ♀, denuded of wax, moderately dense, globular, smooth and shiny. Caudal protuberance short, very dense, surrounded by a coarsely perforated plate.

Antennae 6-jointed, e.g. (1) 34, (2) 27, (3) 74, (4) 20, (5) 17, (6) 30μ.

Legs short, e.g., coxa 50, femur + trochanter 110, tibia 78, tarsus 50μ.

Integument moderately dense, appearing, under the high power, finely rugose, with numerous, widely scattered, small, transparent pores. Stigmatic clefts almost obsolete, indicated by a small group (8 or 10) of short obconical spines and a few simple glands.

Habitat: On rhenosterbosch (*Elytropappus rhinocerotis*, Less.); collected by Messrs. Watermeyer Bros., Aberdeen, C.P., November 1915.

Collection No.: 94.

238. **Ceroplastes zonatus,** Newst.

Ceroplastes zonatus, Newstead, Bull. Ent. Res. viii, p. 32, 1917.

"Female test. Broadly ovate in outline, highly convex; marginal plates very faintly indicated, but apparently without nuclear spots; dorsal plate very large, with a central nuclear spot of white wax; cephalic margin slightly clypeate; lateral margins in very old examples with a pronounced foot-like extension from each of the stigmata, from which there extends a thick white waxen appendage. In the younger forms the foot-like extension is wanting, but the white waxen appendages are present and always porrected. Colour creamy white, suffused with very pale brown; dorsal plate surrounded by a shaded wavy zone of dark brown and brownish black, with here and there a suffused patch of dull flesh-colour. In very old examples the zone of colour extends to the margins and is of a shining madder-brown to piceous colour. On the removal of the outer surface of the test with chloroform, it is seen to be divided into seven areas by pale orange-coloured lines; a central polygonal area, corresponding to the area occupied by the dorsal plate, from the angles of which radiate to the margin single lines marking off the areas of the lateral and cephalic plates.

"Female adult (denuded of the test). Ovate; cephalic margin clypeate; dorsum low and wrinkled; two large, bilateral, submarginal extensions, both longitudinally striated: the space between these extensions of the body-wall and

the margin markedly constricted. Dorsum with a large keel-like process. Caudal process very short and conical. Stigmatic clefts deep. Antennae of eight segments; the articulations relatively very broad; 3rd about equal in length to the 7th and 8th together; a very long hair on the 2nd and 5th, and a slightly shorter one on the 8th; there are two spines on the 8th and one on the 7th. Legs normal. Stigmatic spines covering a large and somewhat pyriform area, the length of which is nearly equal to twice the length of the antennae; the spines, with the exception of a small group near the stigmata, are obconical and the space between them with bands of dark granular bodies, which collectively form a polygonal reticulation; the small proximal group of spines are longer than the others and pointed. No trace of marginal spines. Derm thin and transparent after maceration; rather thickly set with minute pores and minute scattered spines. Caudal process surrounded by a porose zone of brown chitin. Length 3·9–4·6 mm." (Newstead).

The above description does not refer to the mature female forms which attain, with the waxy test, 14 mm. long, 12 mm. broad and 8 mm. high. The colours remain the same except that the lighter parts become yellowish.

When mature the denuded female is densely chitinous, brownish black, with the dorsum smooth, shining. In boiling KOH it stains the liquid deep purplish brown. The antennae are sometimes 7-jointed with joint 4 very long, obviously 4 + 5 of the 8-jointed form.

Habitat: On *Acacia* sp., Pretoria, November 1914.

Collection No.: 344.

Genus **Inglisia,** Mask.

Adult female more or less conical, covered above by a glassy shield which is divided into plates and striated with rows of air cells. Legs and antennae well developed.

239. **Inglisia elytropappi,** sp. n.

Test of adult ♀ small, 1·6–2 mm. long, 1·2 mm. wide and high, like a small bivalve shell with its hinge uppermost standing on the stem. It is very like a small *zizyphi* test but paler in colour, with the upper angles of the two halves smooth instead of tuberculate. The colour is white to pale buff, shiny, often pearly, with the vertical striae conspicuous.

♀, with the test removed, shiny dark brown, of the same general shape as the test, with the apex depressed between two rounded lateral humps.

Cleared and mounted the body is hyaline. The margin has a close-set row of short conical spines with broad bases and moderately sharp points. The stigmatic clefts are obsolete, but their presence is indicated in the marginal row of spines by the addition of a single, slightly longer spine with a narrower base.

The antennae are rudimentary, appearing in varied forms with very indistinct segmentation ranging from 4 to 7-jointed. When 7-jointed the segments are generally very short—mere rings. The measurement of such an antenna gave the following in μ:—(1) 17, (2) 6, (3) 17, (4) 6, (5) 10, (6) 6, (7) 6.

Legs rudimentary, appearing as though composed of three, almost equal, cylindrical segments with a minute claw. The total length varies between 70 and 90μ.

Habitat: On the thinnest twigs of rhenosterbosch (*Elytropappus rhinocerotis*, Less.), Groot Drakenstein, Somerset West and Cape Flats, C.P. (Cape Coll. No. 1244). The stems of the host-plant are thickly covered with "sooty" fungus, apparently grown on secretion from the numerous specimens present.

Collection No.: 100.

240. **Inglisia geranii,** sp. n. (Plate iv, fig. 249).

Insects congregated on the main stems at or near the nodes. Adult insect, with test, about 2·5 mm. long and 1·3 mm. broad at the base, brown, with the air spaces of the test almost colourless and appearing as transverse lines radiating from the centre of each half of the test. The test is composed of two similar halves, each of which simulates a shell or tortoise-shell, with their apices widely separated. The median line at the point of union of the two is almost flat, very little depressed. The test easily flakes away from old specimens and is then white, almost hyaline.

The antennae are 7 or 8-jointed; range in μ:—7-jointed: (1) 24–31, (2) 14–20, (3) 41–48, (4) 17–20, (5) 14–20, (6) 14–17, (7) 20–24; 8-jointed: (1) 24, (2) 17, (3) 31–34, (4) 14, (5) 14–17, (6) 14–17, (7) 17, (8) 24.

Leg I: coxa 68; femur + trochanter 136; tibia 109; tarsus 85μ. The trochanter has a long (90μ) spine. The upper digitules are long and slender, hardly perceptibly clubbed; lower digitules comparatively short and slender.

Anal plate about 115μ long, with 2 or 3 stout spines. Margin with a single row of sharp pointed spines of varying lengths; these are all broad at the base and taper rapidly to the point. Stigmatic cleft with a single spine a little longer than the longest of the marginal series and a little less tapering.

Habitat: On geranium, King Williamstown, C.P.; collected by A. Kelly, March 1916. Fresh material sent by Mr. J. Hobson, King Williamstown, May 1916.

Collection No.: 99.

This species is remarkably close to *Inglisia theobromae*, Newst., which was described on cacao from Uganda, but it is smaller, and joint 3 of the antennae is apparently always longer than 4. It is also somewhat like *I. bivalvata*, Green, but the dorsal shield, formed by the inner sides of the two halves of the test, is wider and more oval.

241. **Inglisia zizyphi,** sp. n.

Test of adult ♀ shaped like a small bivalve shell, standing erect, with the two halves separated by a conspicuous furrow, and the hinge uppermost, represented by two small, rugose "crowns" of the two halves. The lower margins, which rest on the stem, are surrounded by a slight fringe of fine glassy filaments. The test is pale horn-colour, with the distinct vertical striae appearing slightly iridescent. Length 2 to 3 mm.; width 1·5 to 2 mm.; height about 2 mm.

Adult ♀, with the waxy test flaked off, red-brown, of the same shape as the test but with the dorsum shiny and wrinkled.

Cleared and mounted the integument is thin and hyaline. Margin with a dense series of stout conical spines, so closely set that the row appears, in places, double. The derm is clear except for a double row of large simple glands extending along the median line from the anal plates to the middle of the dorsum.

Antennae 5 or 6-jointed, the individual segments badly defined even in stained preparations; range in μ:—5-jointed: (1) 24, (2) 14, (3) 41–51, (4) 24–34, (5) 24–27; 6-jointed: (1) 20–24, (2) 10–14, (3) 48–51, (4) 10–17, (5) 14, (6) 20–24.

Legs short but normal, e.g., coxa 41; femur + trochanter 102; tibia 75; tarsus 58; claw 17μ. Anal plates about 90μ long, each with two fairly stout spines about 40μ long. Stigmatic clefts obsolete.

Larva about 390μ long; antennae 6-jointed; caudal setae very long (170μ).

Habitat: On *Zizyphus* sp., Pretoria; collected by the writer, December 1914.

Collection No.: 101.

This species is very close to *I. conchiformis*, Newstead, but is smaller and has an antennae of 5 or 6 segments instead of 7. I thought at first that I was dealing with young individuals of Newstead's species but mounted specimens contain well developed embryonic larvae.

Genus **Cryptinglisia,** Ckll.

" A Lecaniine Coccid having a glassy covering containing air-spaces, and retaining the legs and antennae (7 or 8 joints) in the adult. Living in galls on the roots of *Vitis*. Differs from *Inglisia* in its mode of life; in the glassy scale not being divided, tortoise-like, into plates; and in the air-cells running together, forming long air-spaces. Larva ordinary, with six large bristles on the cephalic margin. Male unknown." (Ckll.)

242. **Cryptinglisia lounsburyi,** Ckll.

Cryptinglisia lounsburyi, Ckll., The Entom. xxxiii, p. 173, 1900.

Cryptinglisia lounsburyi, Lounsb., Rep. Ent. Cape Good Hope, p. 54, 1900.

" Adult female about 2½ mm. long, soft, shiny, very dark brown, covered with a semi-transparent, brittle, glassy scale. Skin transparent and colourless on boiling in KOH; mouth-parts moderate, rostral loop not very long; margin with a row of simple spines, brownish, about 24μ long, placed close together; anal lobes ordinary, about 160μ long, yellowish brown, surrounded basally by a large, thick, dark brown, chitinous plate, more or less semilunar in form, with the ends produced; a row of small round glands in the middle line from one end of the body to the other, but best developed posteriorly; antennae and legs pale; legs ordinary, femur plus trochanter about 120, tibia about 96, tarsus about 78, claw about 20μ; claw-digitules about as long as claw, with large knobs; tarsal digitules long, with distinct knobs. Antennae 7 or 8-jointed, having three types, thus: (1) 7-jointed with a short 3, all the joints subequal, 21 to 30μ; (2) 7-jointed with a long 3, which is about 41μ long; (3) 8-jointed, with 2 quite short, and 3 and 4 each about 30μ long. The terminal joint is always short, 21 to 26μ.

" These insects occur underground on the roots of grape vines, living in galls which are more or less globular, 4 to 5 mm. diameter, dark, rough and often nodulose on the outside, often aggregated together in numbers, or even coalescing, so that the root presents a nodulose thickening 6 or 7 mm. in diameter and over 20 mm. long. On breaking open the galls, which are quite hard, one finds a cavity containing the Coccid. Small stones are frequently embedded in the sides of the galls.

" *Hab.* Constantia, Cape Colony, at the roots of Stein and Reisling grapes (*Vitis vinifera*). Mr. Chas. P. Lounsbury, sending the specimens, says ; ' None were observed more than eight or nine inches from the surface, and all were on fibrous roots. As you will observe from the specimens, they are somewhat gregarious ; ofttimes one or two rootlets will be quite covered, while all the others are free. Most of the infested vines were backward in growth—some almost dead ; but their condition, I think, is due to other causes than the attack of the insect. Some apparently healthy vines were noticed to be affected." (Ckll.)

This species has not been re-discovered.

Collection No. : 105.

Genus **Parafairmairea,** Ckll.

Female scale divided by a longitudinal, median suture into two halves, each with minute grooves radiating from its apex but not striated with air cells. Legs and antennae well developed, the latter 7 or 8-jointed.

243. **Parafairmairea patellaeformis,** sp.n. (Plate iv, fig. 250).

Adult ♀ dull brown, 9 mm. long and 5 mm. broad, covered above by a stout shield which is divided longitudinally into two halves. This shield has the wavy lines and exact appearance of one of the common shells of the more elevated " Patella " type.

With the covering removed the insect is glossy brown with wrinkles and ridges radiating from a two-fold dorsal peak to the margin.

Antennae 7 or 8-jointed ; range in μ :—

I.	II.	III.	IV.	V.	VI.	VII.	VIII.
20–31	20–24	41–68	34–41	20–27	14–24	20–34	–
20–31	20–24	44	17–34	27–34	17–20	14–20	24–34

Leg I : coxa 88–102 ; femur + trochanter 187–238 ; tibia 160 ; tarsus 90 ; claw approximately 20μ.

Anal plate about 160μ long. The integument is thin and hyaline, without conspicuous hairs or glands. The margin has a single row of short, conical spines of the *Inglisia* type, amongst which are intermingled, at intervals, smaller spines of a thinner type. The stigmatic clefts are obsolete, merely indicated by a scant series of small circular, simple glands extending inwards from the margin towards the spiracle.

Remarks : This is the third *Parafairmairea* to be described. The other two were described on grass, one from France and the other from Surrey, England.

Habitat : On stems of *Acacia karroo* ; collected by A. E. Kelly at Port Alfred, C. P., March 1915.

Collection No. : 98.

Genus **Ceroplastodes,** Ckll.

Female scale convex, but not cone-shaped ; not divided into two halves, nor into distinct plates, but rough or beset with protuberances. ♀ with antennae 7- or 8-jointed.

244. **Ceroplastodes bituberculatus,** sp.n. (Plate iv, fig. 251).

Test of adult ♀ about 4·5 mm. long and 3 mm. broad and high, white, with two prominent humps, one at each end of the median ridge ; margin with a distinct white fringe. The test indicates the anal cleft and has a small prominence over the anal lobes.

Male scale dull white, with the median area denser, about 1·5 mm. long, divided into plates in the normal manner.

Adult ♀ with the waxy covering removed, dark brown, of similar shape to the test. Integument, when mounted, clear, hyaline, without glands or hairs. Margin with a single, close-set row of tubular spines somewhat of the *Inglisia* type but more linear and truncate. Stigmatic clefts obsolete but indicated in the marginal series of spines by the addition of three stigmatic spines ; laterals slender, a little longer than the marginal spines ; median stout, two and a quarter times as long as laterals (116μ).

Legs and antennae long, well developed. Antennae 8-jointed ; range in μ : (1) 27–34, (2) 20–34, (3) 63–68, (4) 31–34, (5) 37–48, (6) 17–20, (7) 17–20, (8) 34–41 (from 5 antennae).

Leg I : coxa 78 ; femur + trochanter 176 ; tibia 120 ; tarsus 90 ; claw 24μ. Tarsal digitules very long, slender, clubbed ; claw-digitules comparatively slender.

Anal plates about 145μ long, apex with 4 very stout blunt spurs.

Habitat : On stems of native shrub, Somerset West, C.P. ; collected by T. F. Dreyer, November 1906. Also at Stellenbosch (Fuller).

Collection No. : 327.

Genus **Idiosaissetia,** nov.

Adult ♀ secreting a thin brittle covering of waxy material not divided into plates or two halves, and without air cells. Legs and antennae present but rudimentary. Anal cleft not median but to one side.

Type, *I. peringueyi*, sp. n.

245. **Idiosaissetia peringueyi,** sp. n.

Adult ♀ about 2·6 mm. long and 1·3 mm. broad, elongate, very convex, with almost perpendicular sides and sloping abruptly in front and behind.

Female raised on a hollow waxy sheath which extends over the sides of the body, leaving the dorsum naked. The material is now ten years old and appears as though the waxy covering had once extended over the dorsum, but had become detached from it. If this were covered the insect would look like an *Inglisia*, except that the waxy covering is thin, pale buff-coloured and solid, i.e., without air-tubes.

Female, denuded of wax, densely chitinised, brown, shiny.

When cleared and mounted the integument of the dorsum is moderately dense, with numerous ± circular clear spaces as in *Saissetia* but of greatly varying size. The venter is thin and clear. The antennae are rudimentary, usually with about

three indistinct joints, always exhibiting pseudarticulations. In the longest antenna seen, after staining, one could observe 6 ill-defined joints measuring (1) 17, (2) 14, (3) 14, (4) 14, (5) 14,(6) 20μ.

Leg I : coxa 34 ; femur $\pm$ trochanter 85 ; tibia 85 ; tarsus 27 ; claw 17μ.

The margin has a scant series of short, curved, moderately stout spines, except near the anal cleft, where the spines are closer set, long (41μ), straight and very acute. The anal cleft is invariably thrown to one side and is not in the median line as in *Lecanium*. The anal ring has numerous (12?) hairs ; anal plates about 120μ long. Embryo-larva large, about 420μ long, with 6-jointed antennae. Caudal extremity produced, with prominent caudal lobes, each with one long, stout seta (136μ) and several shorter spines.

Habitat : On grass or thin reed. Label in tube reads : " From Dr. Peringuey, S.A. Museum, Nov. 1908."

Collection No. : 140.

Genus **Membranaria,** nov.

Lecaniid, somewhat like *Pulvinaria* but with the cottony ovisac replaced by a membranous receptacle. Antennae and legs well developed, the former 7 or 8-jointed.

Type, *M. pretoriae*, sp. n.

246. **Membranaria pretoriae,** sp. n. (Plate iv, fig. 247).

Adult ♀ with ovi-receptacle about 5·5 mm. long, 2 mm. broad and 3 mm. high. Receptacle membranous, secreted from the margins, particularly the posterior margin, of the insect, so that, when completed, the insect, except the head end, is raised from the stem. The membrane consists of two coats, both thin, but which may be readily separated. The outer coat is pale, honey-comb yellow, not striated, and is produced from the upper margin of the insect. The inner coat is paler in colour and has longitudinal striae. The completed receptacle is hoof-shaped (fig. 247) with a distinct, dense, longitudinal, median keel. Its greatest length, along this keel, is about 3 mm.

The adult ♀ is deep caramel-brown, sometimes speckled with black, glossy, with a rounded, median ridge and marginal corrugations and depressions. Cleared and mounted the adult ♀ is moderately dense. Margin with a single row of simple, hair-like spines set wide apart. Submarginal area, except of anterior end, with a broad band of very numerous, small, gland pores, each with a curved, linear gland tube. Stigmatic cleft obsolete, but indicated by a pair of curious, short, broad, cup-like protuberances. Anal ring with 8 hairs ; anal plates surrounded in front by a dense, rugose, chitinous plate.

Antennae 7 or 8-jointed ; range in μ :—

I	II	III	IV	V	VI	VII	VIII
20–31	31–34	17–41	20–48	17–24	17–24	24–27	—
24–27	27–37	24–34	14–24	20–27	17–20	16–20	24–27

Leg I : coxa 102, femur + trochanter 238, tibia 153, tarsus 51, claw 20μ.

Habitat : On crowns of grass, in front of Union Buildings, Pretoria ; collected by the writer, October 1914.

Collection No. : 83.

EXPLANATION OF PLATE I.

Fig. 233. *Lecanium elongatum*, Sign., adult ♀♀.

234. *Saissetia persimilis*, Newst., adult ♀♀.

235. *Pulvinaria mesembryanthemi* (Vall.) Sign., adult ♀♀ with ovisacs.

236. *Filippia carissae*, sp. n., adult ♀ with ovisacs completed and one ♂ puparium.

237. *Saissetia subpatelliforme*, Newst., adult ♀♀.

238. *Hemilecanium theobromae*, Newst., adult ♀♀.

SOUTH AFRICAN COCCIDÆ.

EXPLANATION OF PLATE II.

Fig. 239. *Ceroplastes eucleae*, sp. n., adult ♀♀.

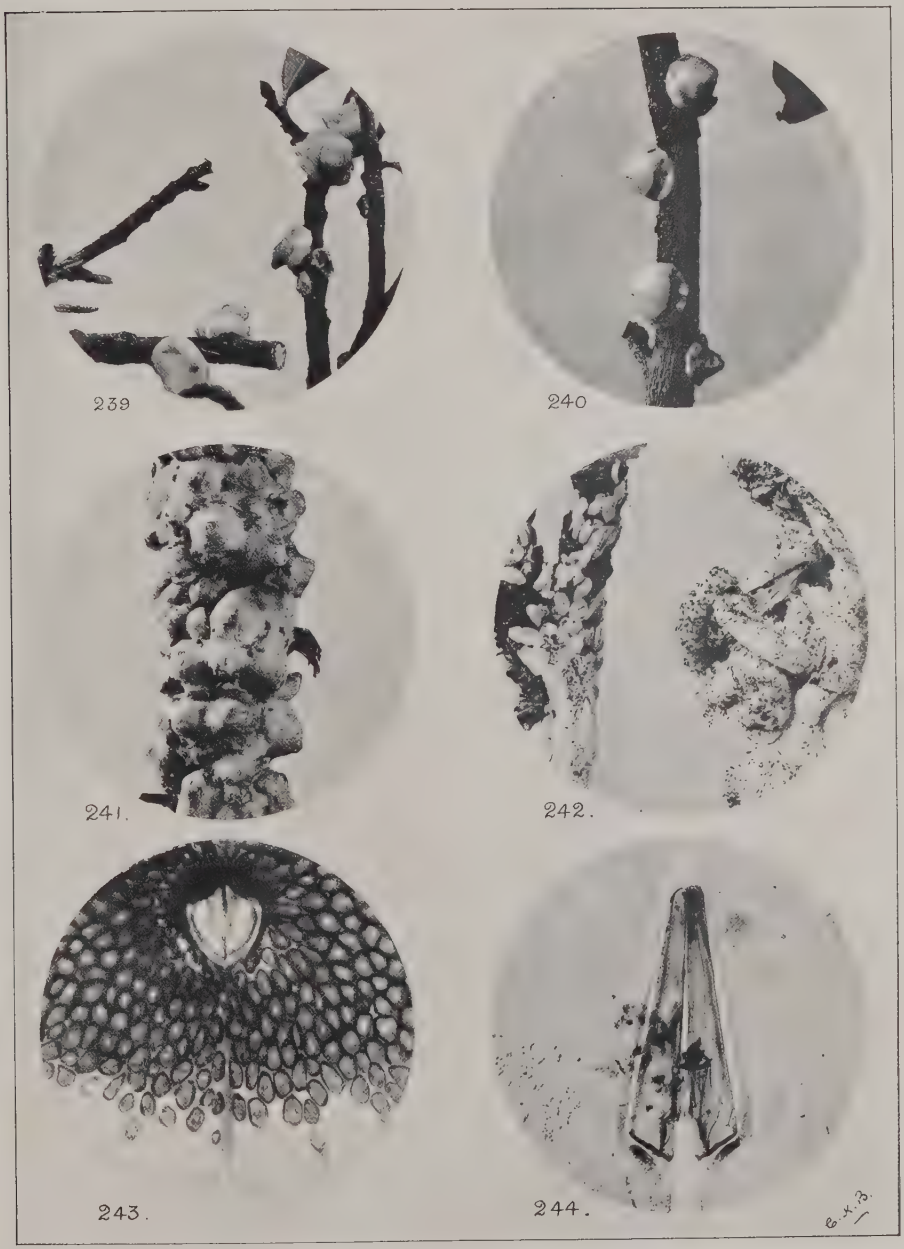
240. *Ceroplastes* sp.

241. *Ceroplastes mimosae*, Sign., adult ♀♀.

242. *Pulvinaria aristolochiae*, Newst., ♂ tests and ♀ ovisacs with larvae.

243. *Saissetia* sp., to illustrate dermal cells.

244. *Protopulvinaria piriformis* (Ckll.) Lefroy, anal lobes of adult ♀.

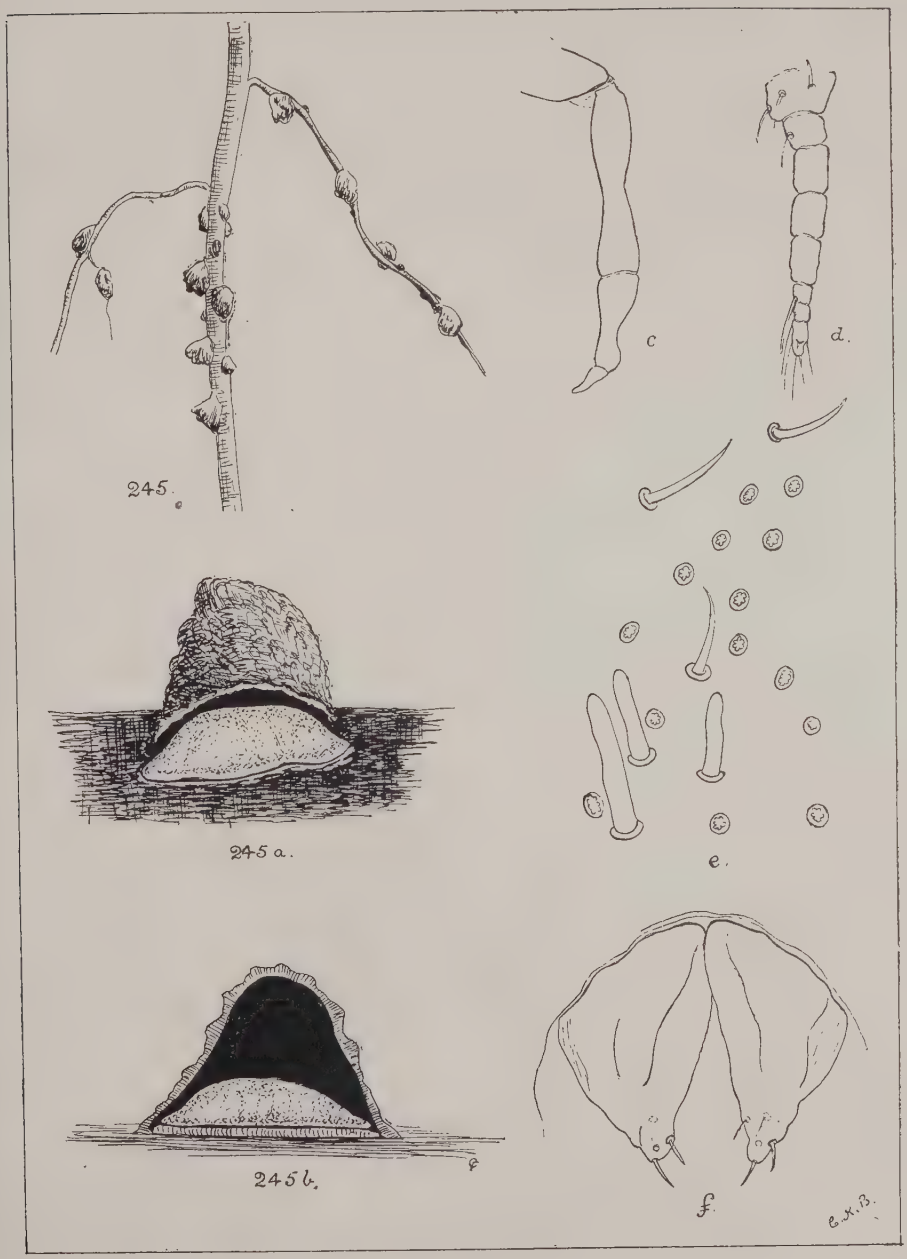


SOUTH AFRICAN COCCIDÆ.

I. B.
E.

EXPLANATION OF PLATE III.

Fig. 245. *Conofilippia subterranea*, sp. n., ♀ ovisacs on roots ; *a*, ♀ with top of ovisac tilted to one side ; *b*, section of ovisac with ♀ ; *c*, swollen tibio-tarsa joint ; *d*, antenna ; *e*, stigmatic spines and glands ; *f*, anal lobes of ♀.



SOUTH AFRICAN COCCIDÆ.

EXPLANATION OF PLATE IV.

Fig. 246. *Allopulvinaria subterranea*, sp. n., adult ♀♀.

247. *Membranaria pretoriae*, sp. n., adult ♀♀.

248. *Protopulvinaria piriformis* (Ckll.) Lefroy, adult ♀♀.

249. *Inglisia geranii*, sp. n., young and adult ♀♀.

250. *Parafairmairea patellaeformis*, sp. n., adult ♀♀.

251. *Ceroplastodes bituberculatus*, sp. n., adult ♀♀ and ♂ puparia.

SOUTH AFRICAN COCCIDÆ.

THE PERCY SLADEN TRUST EXPEDITION TO THE INDIAN OCEAN IN 1905, AND 1907–1909, UNDER Mr. J. STANLEY GARDINER, M.A.

DIPTERA: TABANIDAE.

By Major E. E. Austen, D.S.O.

The material belonging to this family brought back by the expedition includes representatives of only four species, one of which, however, is apparently new. That three out of the four species obtained should belong to the *Aegophagamyia-Bouvierella* group is not surprising, in view of the predominance of this group in the Malagasy Subregion.

Through the courtesy of the authorities of the Percy Sladen Trust, the type of the new species described below has been placed in the British Museum (Natural History).

Pangoniinae.

Genus **Aegophagamyia,** Austen.

Ann. Mag. Nat. Hist. (8) ix, p. 12 (1912).

Aegophagamyia terticeps, Austen.

T. cit., p. 15.

Three ♀♀, from Astove I., 1907; four ♀♀ from Aldabra, 1908–9 (*J. C. F. Fryer*).

The type and para-type of this species, in the British Museum (Natural History), are from Astove I. (*P. R. Dupont*).

In the female sex, at any rate, this species bears a superficial resemblance to *Tabanus albipectus*, Big., for which on casual inspection it might easily be mistaken. The four specimens noted above as having been taken in Aldabra bear the same number as that attached to the examples of *Tabanus albipectus* collected in the same island, by Mr. J. C. F. Fryer, showing that the field note printed below under the heading *T. albipectus* must be taken as applying to the present species also.

Genus **Bouvierella,** Surcouf.

Bull. Mus. Hist. Nat., Paris, 1909, p. 176.

Bouvierella alluaudi, Giglio-Tos.

Scione allaudi, Giglio-Tos, Ann. Soc. Ent. France, lxiv, p. 357 (1895).

Of this species, originally described from specimens from the Seychelles Is., the present collection includes no fewer than twenty-two examples, as follows:— One ♂, one ♀, from Mahé, Seychelles, v-xii. 1905 (*J. S. Gardiner*); eleven ♂♂, five ♀♀, from Mahé, Seychelles (5 ♂♂, 2 ♀♀, from the Forêt Noire district, x-xi. 1908, and 6 ♂♂, 3 ♀♀, from Cascade Estate, at 800 to 1,000 feet or more above sea-level, 1908–9); one ♀, from Félicité, Seychelles, xii. 1908; 2 ♂♂, from Praslin, Seychelles, xi. 1908; and one ♀ from Cosmoledo Is., 1907 (*H. P. T.*).

Bouvierella inornata, sp. n.

♀.—Length (2 specimens) 10 to 11·2 mm. ; width of head 3·25 to 3·6 mm. ; width of front at vertex 0·4 mm., at lower extremity 0·25 mm. ; length of wing 9 to 10 mm.

Sombrely coloured species, entirely devoid of markings ; *ground-colour of dorsum of thorax drab* or dusky drab, that of dorsum of abdomen greyish fuscous* ; *front in* ♀ *narrow, slightly narrower at lower extremity than at vertex, about six times as long as its width at upper end* ; *wings, especially portion beyond basal and anal cells, strongly suffused with brownish, stigma well marked* ; *coxae drab, legs otherwise blackish brown, extreme tips of femora, at least of those of front pair, ochraceous buff.*

Head : front, subcallus, face, sides of face and jowls drab, occiput smoke-grey ; vertex clothed with minute, erect, blackish-brown hair, sides of face with ochraceous-brownish hair, basi-occipital region with longer fine brownish hair ; *frontal callus* represented by a fine, dark, median line, commencing at some distance above level of lower inner angle of eyes, and not reaching anterior ocellus ; *proboscis*, including labella, narrow and elongate, total length of proboscis about two-thirds of that of head ; proximal joint of *palpi* dark brown or brownish, terminal joint similarly coloured on outer surface, narrow, curved, elongate and very slender ; *antennae* dark brown, first and second joints clothed above and below with short, blackish hair, expanded portion of third joint ovate or elongate ovate when viewed in profile, without any angle on upper margin, annulate portion of third joint narrow, curved and elongate. *Thorax* : dorsum clothed with short, recumbent brownish hair, which in front of prescutellar groove may be mixed with paler hair, scutellum bearing longer brownish hair, or a mixture of brownish and ochraceous hair ; pleurae and pectus agreeing in coloration with dorsum, and clothed with fine, brownish hair. *Abdomen* : dorsum clothed with short, appressed dark brown hair, venter agreeing with dorsum in coloration and hairy covering. *Wings* : lengths (relative as well as actual) of stalks of first and fourth posterior cells variable in different specimens ; stigma elongate, dark brown. *Squamae* light drab or drab-grey, borders drab. *Halteres* : knobs clove-brown or blackish brown, stalks paler (cinnamon-buff). *Legs* sparsely clothed with short or minute dark brown or blackish hair.

Seychelles Is. Type from Silhouette (plateau of Mare aux Cochons, about 1,000 feet, ix. 1908) ; a paratype from Mahé (Cascade Estate, 800–1,000 feet), 1908–9.

Bouvierella inornata is distinguishable from all previously described species belonging to this genus, *inter alia*, by its uniformly sombre coloration, the ground-colour of the thorax and abdomen not being relieved by either lighter or darker markings. In particular, it is distinguished from *B. brunnea*, Surcouf (Bull. Mus. Hist. Nat., 1909, no. 4, p. 179), a species found in Madagascar, by its smaller size, and by the more uniformly dusky coloration of the body and legs, the dorsum of the thorax not being longitudinally striped with grey, and the legs not being reddish yellow, clothed with golden pile.

In the length and slenderness of the proboscis, including the labella, the species just described agrees rather with *Aegophagamyia*, Austen, with which it constitutes in this respect an annectent link ; as regards antennal characters and the shape of the first posterior cell, however, the species seems more correctly placed under Surcouf's genus.

* For names and illustrations of colours, see Ridgway, "Color Standards and Color Nomenclature" (Washington, D. C. : published by the Author, 1912).

TABANINAE.

Genus **Tabanus,** Linn.

Fauna Suecica, Ed. ii, p. 462 (1761).

Tabanus albipectus, Bigot.

T. albipectus, Bigot, Ann. Soc. Ent. France, (3) vii, p. 125, pl. ix, fig. 2 (1859).

Twenty-one specimens, from various localities as follows :—One ♀, from Poivre Is., Amirante Is., v-xii. 1905 (*J. S. Gardiner*) ; one ♀, from I. des Roches, Amirante Is., 15. x. 1905 ; one ♀, from Aldabra, 1907 (*H. P. T.*) ; 15 ♀♀, from Aldabra, 1908–9 (*J. C. F. Fryer*) ; one ♂, two ♀♀, from Long Island and Mahé, Seychelles (Cascade, about 1,000 feet), 1908–9.

A comparison of the foregoing material with the type of the species, taken in Madagascar by Dr. Coquerel and now in the British Museum, places the correctness of the identification beyond doubt. In addition to the type of *T. albipectus*, the National Collection includes a ♂ and ♀ from Astove I. and Aldabra respectively (*P. R. Dupont*), and a ♀ from Pigaduli, Zanzibar, " on goat," 14.x.1912 (*Dr. W. M. Aders*).

To the specimens from Aldabra in the present series, taken by Mr. J. C. F. Fryer, the following interesting field-note was attached :—" Most numerous in December [1908] : attack sea-turtles, biting them between the plates on the back : apparently attack them in water as well as on land. Were seen flying all over the lagoon, and also some way out at sea. They fly strongly, and bite man also." As already explained, this note must be taken as applying equally to *Aegophagamyia terticeps*, Austen (*vide supra*). With reference to the biting of reptiles by blood-sucking Diptera, it may be remembered that the typical series of *Tabanus crocodilinus*, Austen, was taken on a crocodile in Nyasaland (*cf.* Austen, Bull. Ent. Res., ii, p. 285 (1912)), while in Uganda, as is well known, *Glossina palpalis* feeds readily upon crocodiles and monitors.

ON THE REASONS FOR THE VARIATION IN THE EFFECTS OF FORMALDEHYDE AS A POISON FOR HOUSE-FLIES.

By Capt. Ll. Lloyd, D.Sc., R.A.M.C. (T. F.).

The following is an account of an investigation carried out on behalf of the Hygiene Department of the Royal Army Medical College at the suggestion of Prof. Maxwell Lefroy, who, after his visit to the Mesopotamia War Area in 1916, was insistent on the importance of the discovery of some poison for house-flies (*Musca domestica* and allied species) that could be used indoors with safety. The work was carried out in the Entomological Department of the Imperial College of Science in the early part of 1917. Large stocks of flies which were kept breeding in two rooms were available for the purpose.

Formaldehyde has been frequently recommended as a poison for flies, but those who tested its effects gave varying accounts of it. Miss Lodge (1), who studied it in some detail, was unable to account for these variations and stated that no definite conclusions could be drawn from her work. An analysis of the various factors which might cause such variations was made, and it was found that there were three which play an important part. These are (1) impurities in the formaldehyde, (2) the humidity of the atmosphere, and (3) the strength of the solution used.

The following subjects will also be discussed, (4) the advantage of adding a bait, (5) the most effective mode of administration, and (6) comparison with other poisons.

"Formaldehyde" must be understood throughout to mean the 40 per cent. solution in which it is usually sold, and all strengths are given as percentages of this. "Formalin," the trade name of one brand, is often loosely used for this solution.

Impurities in the Formaldehyde.

Formaldehyde is prepared by passing a mixture of heated air and the vapour of methyl alcohol over some heated contact agent, such as copper gauze or silver. The methyl alcohol is crude or pure, but should be 90 per cent., and should not contain more than 1 per cent. of acetone. The purity of the product depends largely on that of the methyl alcohol, and on the freedom of the air from ammonia. The following substances are liable to be present: trioxymethylene, methylal, methyl and ethyl alcohols, acetone, hexamethylene tetramine, methylamine, and formic acid. Prof. Baker, of the Imperial College of Science, provided samples of formaldehyde to which certain of these substances had been added in proportions in which they are liable to occur. Solutions of these, generally in water and soaked up in clean sand, were exposed side by side with solutions of the control formaldehyde in the fly room, and left for twenty-four hours. The numbers of dead flies in the immediate neighbourhood of each were then counted. Many flies left the table to die and no account could be taken of them. There was always a definite group dead in a circle of six inches radius around each jar, and the comparisons were based on these. In order to obviate the influence of the varying numbers of flies on different days, all numbers are given reduced to percentages of the controls. All decisions are based on a number of tests, with the positions of the various solutions and the controls interchanged.

Of the impurities tested, hexamethylene tetramine, methylamine and formic acid were found to be of importance, and these only will be discussed. The effects of the presence of the other substances mentioned above were investigated and found to be neutral, or of very little importance.

Hexamethylene tetramine, $(CH_2)_6N_4$.

This substance is produced by the action of ammonia on formaldehyde. It is liable to occur in the solution owing to the presence of ammonia in the air during manufacture. It breaks down with the formation of methylamine, $CH_3 NH_2$. Formaldehyde containing these bodies has a yellowish colour and a fishy odour, both these characteristics being intensified by the addition of a strong alkali. These substances are distasteful to flies. A sample containing 5 grms. of hexamethylene tetramine added per litre was tested against a control. The residue from the manufacture of this substance, containing ammonia and methylamine, and some methylamine hydrochloride, with and without an alkali to set free the methylamine, were also tested with the following results.

TABLE I.

Showing the Influence of Hexamethylene tetramine in Formaldehyde.

Solution	Percentages of flies killed	Average %	Total flies killed
Formaldehyde control, 10%	100 in each case	100	324
Formaldehyde with 5 grms. hexamethylene tetramine added per litre, 10%	74, 130, 93, 71, 57	85	267

TABLE II.

Showing the Influence of Methylamine in Formaldehyde.

Solution	Percentages of flies killed (actual numbers in brackets)	
Formaldehyde control, 10%	100 (50)	100 (20)
,, with 2·5% hexamethylene tetramine residue 10%	36 (18)	
,, with 1% hexamethylene tetramine residue 10%		65 (13)
,, with 1% methylamine hydrochloride 10%		40 (8)
,, with 5% methylamine hydrochloride and 0·2% KOH 10%	30 (15)	
,, with 1% methylamine hydrochloride and 0·1% KOH 10%		30 (6)

A sample, naturally containing these substances in unknown proportion, with a pale yellow colour and fishy odour (previously unsealed bottle from the store of the Imp. Coll. Sci.) was tested against a colourless control with a clean odour.

The results of the tests are summarised in the next table. In nearly every case the purer sample proved the more effective. No suggestion can be given for the purification of formaldehyde of this nature, and it should be avoided if any other is obtainable.

TABLE III.

Comparing a Yellow Formaldehyde with Fishy Odour (Methylamine) with a Clean Sample.

Solution	Percentages of flies killed	Average %	Total flies killed
Formaldehyde control, 10%	100 in each case	100	1509
,, impure, ,,	134, 67, 96, 89, 230, 36, 17, 68, 58.	89	1118

Formic acid, H·CO·OH.

Formaldehyde is prepared by the dehydrogenation of methyl alcohol: $CH_3OH + O = CH_2O + H_2O$. Theoretically in the process there is no formic acid formed. The samples of formaldehyde examined, however, were all found to be acid. Three which were titrated were found to be +24, +39, and +60 acid (Eyre) respectively. (A fluid " $+x$ acid " requires x ccs. of normal alkali to make one litre neutral.) The acid present was proved to be formic by a test suggested by Dr. A. M. Whiteley. A few ccs. of the formaldehyde are shaken up with lead carbonate and quickly filtered. If formic acid is present crystals of the sparingly soluble lead formate separate out in the filtrate after a short interval. The crystals are minute, very characteristic needles. On the assumption that formic was the only acid present, these samples contained 1·1, 1·8, and 2·76 grms. of formic acid per litre respectively. When the dilute poison 5–10 per cent. formaldehyde is made up the acid would be present in amounts varying from ·0055 to ·0276 per cent. Even these small quantities are detected and disliked by flies.

TABLE IV.

Showing the Deterrent Effect of Formic Acid in Water.

Solution	No. of tests	Av. flies tasting	Av. flies drinking	Av. percentage which drank
Tap water control	2	35	24	69
Formic acid ·1%	1	33	3	10
,, ·05%	3	32	15	47
,, ·02 ·04%	4	36	20	54
,, ·01 ·005%	3	36	18	50

Temperature 77·9° F.; relative humidity 57%.

Testing saucers, two inches in diameter, were filled with solutions of formic acid in water and covered with discs of blotting paper to soak up the fluid. These were then exposed one at a time in the fly room and watched for five minutes, a count

being taken of the numbers of flies which visited and tasted the solution and then left, and of those which remained to drink. Controls were made with tap water. A fly only " tastes " when it presses its proboscis one or more times against the wet surface, and quickly withdraws it. It " drinks " when the proboscis remains pressed against the surface for a few seconds or longer. Apart from the count, an impression may also be gathered from the behaviour of the flies. On a fluid which they find attractive they cluster, but on an unattractive one there are never more than two or three flies at one time. The total number of visiting flies was about constant in each test.

The disadvantages of the presence of formic acid in formaldehyde are shown by the following tests, where a solution containing 12 grms. per litre was tested against the one containing 1·8 grms. per litre. In ten tests the less acid solution killed twice as many flies as the more acid one.

TABLE V.

Showing the Disadvantages of the presence of Formic Acid in Formaldehyde.

Solution	Percentages of flies killed	Av. per cent. killed	Total killed
Formaldehyde 1·8 grms. $H \cdot CO \cdot OH$ per lit. 10%	100 in each case	100	808
,, 12·0 grms. $H \cdot CO \cdot OH$ per lit. 10%	54, 78, 54, 27, 34, 38, 34, 51, 43, 50	50·6	366

Flies are less readily repelled by dilute alkaline than by acid solutions, and will drink solutions containing 0·1 to 0·2 per cent. caustic potash, or 0·07 per cent. lime, as readily as water. There is possibly even a little attraction in it. The following Table VI shows this, the data being obtained in the same way as those in Table IV.

TABLE VI.

Showing that certain weak Alkaline Solutions are not deterrent.

Solution	No. of tests	Av. flies tasting	Av. flies drinking	Av. percentage which drank
Tap-water control	5	38	31	83
KOH 2%	1	35	0	0
,, 0·3–0·4%	2	31	14	45
,, 0·1–0·2%	2	34	30	91
$Ca(OH)_2$, 0·14% (lime water)	2	37	20	54
,, 0·078%	2	33	20	61
,, 0·07%	3	37	30	81

Temperature 77° F.; relative humidity 57%.

It is therefore advisable always to add as much alkali to the formaldehyde as possible, without deterring the flies, to neutralise any formic acid which may be present, or any which may be formed by oxidation during the exposure of the solution. Table VII shows the benefit of the procedure.

TABLE VII.

Showing the Advantages of adding certain Alkalis to Acid Formaldehyde.

Solution, 10% in each case	Percentages killed (actual numbers in brackets)
Control formaldehyde (12·5 grms. H·CO·OH per lit.)	100 in each case
,, +50% lime water in dilution	283 (155), 241 (82)
,, +K_2CO_3, 15 grms. per. lit. (equiv.).	300 (36), 268 (147), 270 (92)
,, +$(NH_4)_2CO_3$, 10 grms. per lit. (equiv.).	68 (37), 82 (28)
Control formaldehyde (1·8 grms. H·CO·OH per lit.)	100 in each case
,, +100% lime water in dilution	76 (47), 90 (923)
,, +50% ,, ,, ,, ,,	114 (269), 104 (312), 142 (57)
,, + 1% K_2CO_3	125 (50)
,, + 1% NH_4OH	50 (20)
Control formaldehyde (1·1 grms. H·CO·OH per lit.)	100 in each case
,, +50% lime water in dilution	131 (297), 124 (31)
,, +25% ,, ,, ,, ,,	110 (28)

It will be seen that the addition of the alkali improved the effect in every case except when the whole fluid of dilution was lime water, which made it too strongly alkaline, and when ammonia was used, methylamine being formed in these cases. Lime water is recommended in practice in preference to other alkalis because it is a weak solution of definite strength. It is prepared by allowing cold water to stand over lime, slaked or unslaked, for a few hours and then filtering the solution before use. Such a solution contains 0·14 per cent. $Ca(OH)_2$. If made with hot water the solution is weaker. The maximum amount, half the total fluid of dilution, should always be used to counteract the formic acid which would otherwise be formed after dilution, during exposure to the air, or by the bodies of dead flies falling in. In a trap which will be presently described, but an imperfect model, which was exposed in the fly room, this was very clearly shown. The fluid in the trap was 7·5 per cent. formaldehyde, 35 per cent. lime water (equivalent to the acid present), and 5 per cent. sugar. On the first three days this trap killed 1,800 flies, and then became ineffective. Four flies had crept into the poison, and when this was titrated it was found to have become +2 acid. An equivalent of KOH was added and it became again effective.

Humidity of the Atmosphere.

A test was made at a temperature of 96° F., and the poison was found to be effective. There is no reason apparent why it should not be effective in a tropical country. The humidity of the air, however, plays a considerable part, as indeed

it must with any poison which is administered as a drink. In wet weather flies have less inclination to drink and there is more moisture available, so that they are less likely to discover the trap. Experiments were made to test this.

(i). A jar with an area of 2·5 sq. in. was filled with sand wetted with a 10 per cent. solution of formaldehyde without any addition. It was placed in the centre of a dish of dry sand, area 95 sq. in., and this was placed in a greenhouse containing a large number of flies. No water was available and the atmosphere was dry. After twenty-four hours 1,560 dead flies were counted on the surface of the sand, or within a few inches of the dish. The experiment was repeated with approximately the same number of flies available and the same atmospheric conditions, but in this case the sand in the surrounding dish was wetted with water, equally with the poisoned surface. After twenty-six hours only 20 flies were found dead, the majority having obtained their water from the unpoisoned surface.

(ii). This series was carried out in a glass cylinder 24 in. high and 10 in. in diameter. Wet and dry bulb thermometers were included. The formaldehyde (10 per cent. in water) was supplied soaked up in sand, area 2·5 sq. in. The duration of each experiment was twenty-two hours. The air was in no case quite dry, as the amount of moisture given off by the poisoned surface is considerable in this confined space. It was found that the formaldehyde was effective with a relative humidity of 76 per cent. and 72 per cent., that its effect was about halved with a relative humidity of 81 per cent., and that above 90 per cent. it was much reduced, available water being present throughout in this case. The results are given in Table VIII. From these it may be concluded that liquid poisons will not be very effective if much other available moisture, such as dew, is present. Formaldehyde works well in a room where there is a wet sink, as was the case in the fly room where these experiments were performed. It would be useless, however, to place the poison in the sink or immediately over it, though it will be found very effective a few feet away. Flies are usually going about looking for food, and seem to taste all moisture they come across in their wanderings, either in the hope of its containing food or simply for the sake of the drink. Their capacity for utilising solid food depends on whether the crop contains fluid with which to dissolve it.

TABLE VIII.

Showing the decreasing effect of Formaldehyde with increasing Humidity.

Conditions in Cylinders	Temp.	Rel. Humid	Total flies	Percentage killed
$CaCl_2$ added to dry the air	79·1°	72%	229	94
Air not treated	74·9°	76%	125	89
Wet blotting paper as base	77·0°	81%	66	47
Wet blotting paper as base and top	76·3°	93%	90	17

(iii). Experiments with baited formaldehyde under saturated conditions were made. It was found that the baits about doubled its efficacy, but the results were still very unsatisfactory. The details are given below in Table IX. Sugar in water was the bait and the formaldehyde was employed in various strengths, being supplied

in two-inch saucers with blotting-paper covers. Each series was continued for two days and the cylinders were kept as wet as possible, though in several cases they dried somewhat towards the end, with a corresponding increase in the death-rate. The controls were on a dry table with muslin tops to the cylinders, the relative humidity being about 76 per cent. The fourth experiment in Table VII is taken as a control for the saturated conditions with unbaited formaldehyde. To obtain a proper estimate the percentages dead at the end of twenty-two hours should be studied. Another series carried out in precisely the same way, but with bread-water as a bait instead of sugar, gave very closely similar results and will therefore not be detailed.

TABLE IX.

The effect of Baited Formaldehyde compared under Wet and Dry Conditions.

Solution	Conditions	No. of flies	Percentages dead after :		
			5 hrs.	22 hrs.	48 hrs.
No bait, formaldehyde 10%	wet	90		17	
Sugar 5% ,, ,,	dry	38	32	97	100
,, ,, ,, ,,	wet	34	3	35	79
,, ,, ,, 7·5%	dry	32	44	91	100
,, ,, ,, ,,	wet	28	3	23	69
,, ,, ,, 5·0%	dry	21	43	100	100
,, ,, ,, ,,	wet	23	4	22	78
,, ,, ,, 2·5%	dry	19	21	79	100
,, ,, ,, ,,	wet	17	0	6	82

Humidity and the use of formaldehyde on ships.

Lt.-Col. W. Byam, R.A.M.C., reported that while he found formaldehyde very effective on board ship, it failed to be of use in Egypt. This is in accordance with the variations in the accounts of its utility. That used in Egypt was possibly too acid. Experiments were devised to discover what its effect would be on board ship where the atmosphere is moist, but not necessarily saturated, and where most of the available water is salt, owing to all the woodwork being saturated with this substance.

(1). A cylinder was washed inside with 10 per cent. salt solution, flies were introduced and blotting-paper soaked in the salt solution placed above and below ; a shelter was erected over the poison dish to prevent the salt water dripping in. A control was set up, fresh water being used instead of salt solution. It was found that the flies were poisoned about twice as rapidly in the one with salt water as in the one with fresh water.

(2). This was carried out in cylinders, a bait being used in the poison which was soaked up in jars of sand (area 2·5 sq. in.) that were placed in dishes of sand (area 13·5 sq. in.) wetted in one case with 10 per cent. salt solution and in the other with water. The atmosphere would be very moist from the vapour given off by the wet sand,

TABLE X.

Showing the Effect of Formaldehyde when available Water is strongly saline.

Solution	Conditions	Total flies	Percentages dead after :		
			3 hrs.	28 hrs.	48 hrs.
Formaldehyde 10% in water	Saturated with salt solution	29	14	69	93
Formaldehyde 10% in water	Saturated with fresh water	27	4	39	78

and the conditions would approach those on board ship when it is not actually raining. The results, which are given in Table XI, are very striking, as the flies died rapidly when the available water was saline, and slowly when it was fresh. By further experiment it was found that the flies drink as readily as water a solution of 1 per cent. salt, that stronger solutions deter them, while 5 per cent. and upwards repels them entirely. Formaldehyde properly neutralised and baited will be found very effective on board ship.

TABLE XI.

Showing the Probable Effect of Formaldehyde on Board Ship.

Solution	Conditions	Total flies	Percentages dead after :		
			2 hrs.	5 hrs.	24 hrs.
Formaldehyde 7·5%, lime water 50%, sugar 5%	Salt water available	94	22	43	96
	Fresh water available	38	3	21	63

The Strength of Formaldehyde to be used.

The question as to the most effective strength of formaldehyde was approached from two points of view; firstly, the stronger the solution the less likely are the flies to drink much; secondly, a little of a strong solution, or a large quantity of a weak solution, will kill them. These will be discussed under the headings of "The Deterrence of Formaldehyde" and "The Toxicity of Formaldehyde." The results were then combined, giving the optimum concentration. At the same time control experiments were made in cylinders as a check to the conclusion drawn.

The Deterrence of Formaldehyde.

The deterrence of formaldehyde was determined by the same method as that employed with formic acid, already described. Each series of different strengths was exposed, one at a time and in quick succession, in the same spot where the numbers of available flies were about constant. The numbers which only tasted and the numbers which drank were counted and the percentage of the latter to the

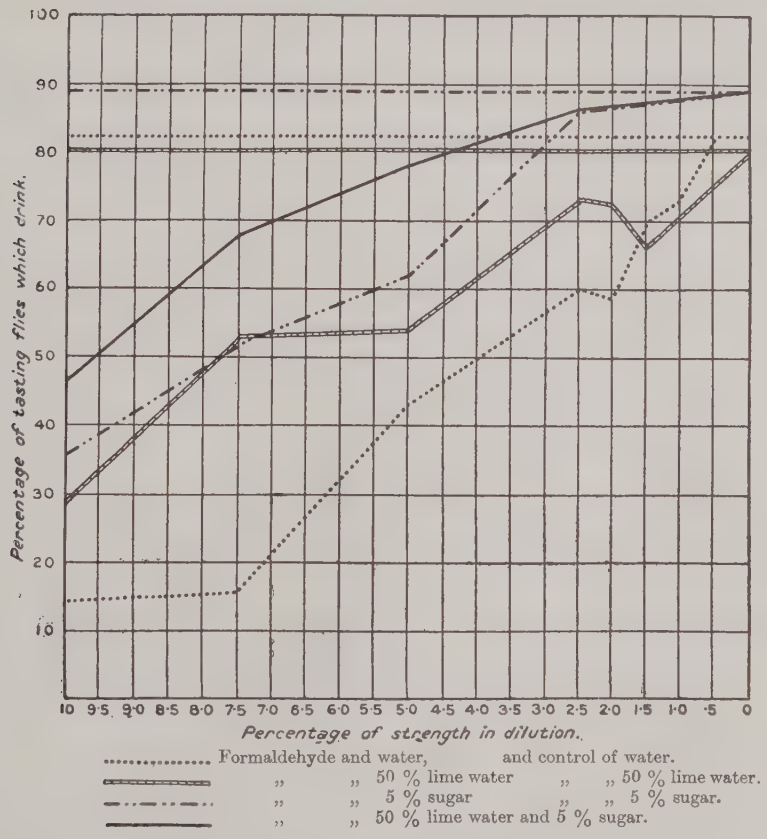

100
90
80
70
60
50
40
30
20
10
Percentage of tasting flies which drink.
10 9·5 9·0 8·5 8·0 7·5 7·0 6·5 6·0 5·5 5·0 4·5 4·0 3·5 3·0 2·5 2·0 1·5 1·0 ·5 0
Percentage of strength in dilution.
Formaldehyde and water, and control of water.
„ „ 50 % lime water „ „ 50 % lime water.
„ „ 5 % sugar „ „ 5 % sugar.
„ „ 50 % lime water and 5 % sugar.

Diagram 1. Showing the deterrence of acid formaldehyde and its remedy.

former gives the factor to the solution. Controls were made with water alone, with 50 per cent. lime water, and 5 per cent. sugar solution, and each series was checked by one or more repetitions. The time allowed to each exposure was five minutes. The following solutions were thus studied: formaldehyde in water; formaldehyde in 50 per cent. lime water; formaldehyde in sugar solution; formaldehyde in 50 per cent. lime water with sugar. The detailed results are given in

Table XII, and in Diagram 1. In the diagram the points represent the percentages of the tasting flies which remained to drink. The bottom dotted line represents formaldehyde and water, and shows that any mixture of these is deterrent as compared to the water control, of which an average of 82 per cent. of the tasting flies drank. The 10 per cent. formaldehyde deterred from drinking nearly 82 per cent. (67 out of 82) of the tasting flies which would have drunk had there been no formalde-

TABLE XII.

Showing the Deterrence of Formaldehyde, and its Remedy.

Solution		No. of tests	Total flies	No. of flies tasting			No. of flies drinking			Percent. of drinking to tasting flies		
				Av	Max	Min	Av	Max	Min	Av	Max	Min
Water controls		8	263	33	48	26	27	35	20	82	95	72
,, formaldehyde	10%	6	221	37	46	30	5	13	1	15	34	2
,, ,,	7·5%	6	190	32	35	27	7	13	0	16	38	0
,, ,,	5·0%	6	195	32	38	26	14	19	9	43	59	24
,, ,,	2·5%	6	221	35	48	26	22	27	15	60	73	52
,, ,,	2·0%	4	148	39	63	24	21	33	13	59	71	52
,, ,,	1·5%	4	151	38	47	29	26	34	19	70	80	64
,, ,,	1·0%	2	75	37	38	37	28	31	26	75	81	70
,, ,,	·5%	2	74	37	38	36	30	31	30	82	83	81
Lime water controls	50%	3	112	37	39	35	30	31	29	80	86	72
,, formaldehyde	10%	4	136	34	42	25	5	11	9	29	36	24
,, ,,	7·5%	4	121	30	40	23	16	21	11	53	71	40
,, ,,	5·0%	4	122	30	33	28	16	21	11	54	67	37
,, ,,	2·5%	4	114	28	31	26	21	23	17	73	85	54
,, ,,	2·0%	2	64	32	33	31	23	25	21	72	76	68
,, ,,	1·5%	2	70	35	39	31	23	27	20	66	69	64
Water, sugar controls	5%	1	45	45			40			89		
,, formaldehyde	10%	2	76	38	45	31	14	21	8	36	46	26
,, ,,	7·5%	2	63	31	36	27	17	23	11	52	63	41
,, ,,	5·0%	2	71	35	38	33	22	23	21	62	69	55
,, ,,	2·5%	2	66	33	35	31	28	31	26	86	88	84
Lime water sugar	50% 2·5%											
,, formaldehyde	10%	2	60	30	30	30	14	14	14	47	47	47
,, ,,	7·5%	2	72	36	41	31	24	29	20	68	71	65
,, ,,	5·0%	2	60	30	35	25	23	27	20	78	80	77
,, ,,	2·5%	2	52	26	27	25	22	24	21	86	89	84

Temp. av. 77° F. (78·9–76·0°). Rel. humid. av. 50% (58–39%).

hyde present, and so on. The line of dashes represents the percentages which drank the formaldehyde in 50 per cent. lime water. It is higher than the previous one because, while the deterrent influence of the formaldehyde remains as before, that of the formic acid is removed. It also is always below the water and lime water controls. The next line of dots and dashes represents formaldehyde and 5 per cent. sugar, without lime water. The presence of the bait has partly counteracted the

deterrence, so that at 3 per cent. it is equal in its attraction to the water control, and at 2·5 per cent. approaches very near to the control of sugar and water. The continuous line represents the mixture which is finally recommended, 50 per cent. lime water and 2·5 per cent sugar. It is equal to the water control at 5·5 per cent., and then becomes more attractive than water because the flies recognise in it a food, while the formaldehyde is not repellent enough in weak solution to deter them in large numbers. At 5 per cent. only 12 per cent. fewer flies drank than would have done so if the solution were sugar and water only. At 2·5 per cent. formaldehyde, only 3·5 per cent. declined to drink. The neutralisation of the formic acid and the addition of the bait have at this point nearly counteracted the deterrent action of the formaldehyde. It is of considerable interest to notice that the lines which represent the formaldehyde with and without lime water are parallel in pairs, while those with and without sugar converge in pairs at 2·5–1·5 per cent. This shows the influence of the presence of formic acid in very dilute solutions. The formaldehyde used proved on titration to be + 60 acid (Eyre) which is equivalent to 2·76 grams of formic acid per litre of formaldehyde. At 5·0 per cent. dilution this is 0·014 per cent. formic acid, and at 2·5 per cent. it is 0·007 per cent. formic acid. The presence of sugar is sufficient to counteract the latter but not the former. A factor which has not been taken into consideration is that the formaldehyde vapour may be deterrent and that fewer flies may taste stronger than weaker solutions. This was not apparent in the open, but showed itself when the experiment was repeated in enclosed spaces. There was then progressive deterrence as the strength of the solution increased, as was shown by the smaller percentage of the available flies which settled on it. The curve of this deterrence is represented by the dotted line in Diagram II. Consideration of it will show that its fall is so gradual that it would not affect the argument even if its influence were as powerful in the open as in the enclosed space, since the influence of the other factors is so much more potent.

The Toxicity of Formaldehyde.

In determining this factor, the solution used was 50 per cent. lime water and 2·5 per cent. sugar, only the percentage of formaldehyde varying. About 50 flies were enclosed in each of several glass basins of capacity of 600 cc. The basins were then placed over saucers containing the poison and a count was taken of the flies that tasted and those that drank. In the first series the time allowed was fifteen minutes, but it was found that all the flies that intended to drink did so in the first five minutes, and the exposure was subsequently limited to this time. The poison was then removed and the edge of the basin slightly raised to allow air to circulate. At the end of one hour and of two hours the numbers lying inert were counted, the difference between the two counts representing the recoveries, as formaldehyde seems to act as an anaesthetic, and its effect in weak solution, or when a very little is taken, is sometimes only temporary. No recoveries were noted after two hours. All the flies were then anaesthetised and counted. Four series of each percentage were thus made. The complete results are summarised in Table XIII. This shows the total and average numbers of flies exposed to each percentage of formaldehyde used (from 2·5 to 20 per cent.) ; the average, maximum and minimum numbers of flies which tasted ; the average, maximum and minimum percentages of those which drank

compared to those which tasted; and the percentages of those temporarily and permanently incapacitated compared with those which drank. The calculation of the numbers of those which died against those which drank is more satisfactory than calculating them against those which only tasted. The numbers thus obtained are frequently above 100, as at a strength of 5 per cent. and upwards the amount taken by a fly in its taste is often enough to kill it. Reference to the table will show that not only the averages, but also the maxima and minima, run in series corresponding to the strength of the poison, allowance being made for occasional variation due to experimental error. The percentage of those which died compared to those which drank gives the factor of toxicity to each strength of formaldehyde. These factors are plotted in Diagram 2 and are represented by the line of dashes. The toxicity increases rapidly from 15 per cent. upwards, and falls rapidly from 5 per cent. downwards, the rise from 5 per cent. to 15 per cent. being gradual. The dot and dash curve is taken from Diagram 1, with the addition of the factors for 15 per cent. and 20 per cent. strengths which are taken from Table XIII. This curve represents the percentage of tasting flies which remain to drink a solution of formaldehyde containing 50 per cent. lime water and 2·5 per cent. sugar. It is the curve of deterrence. By combining these two curves a hypothetical curve is constructed which is represented in the diagram by the continuous line. For example with a strength of 10 per cent. formaldehyde exposed in the open, 47 per cent. of the flies that taste it will remain to drink. Some however will absorb enough poison in the taste to kill them, and the number which finally die is not 47 per cent. of the tasting flies but 133 per cent. of 47, that is, 62·5 per cent. of the flies that taste die. The relative effects of different strengths of formaldehyde, as represented by the curve, were thus found. It is a natural curve with its maximum at 5·0–6·0 per cent. formaldehyde, and this is therefore the optimum strength to use in practise. The straight dotted line in the same diagram represents, as explained above, the deterrence of the vapour at different strengths in enclosed spaces. Its tendency is to recommend the use of as weak a solution as possible, but the decline in the effect below 5 per cent. is so rapid that this factor could play no part in the decision as to which strength to use.

Table XIII.

Showing the relative Toxicity of various strengths of Formaldehyde.

Solution 50% lime water, 2·5% sugar		Tests no.	Total flies	Av. no. flies	% of flies tasting			% of tasting flies which drank			% to drinking flies			
											Down in 1 hour	Dead after 2 hours		
					Av.	Max.	Min.	Av.	Max.	Min.		Av.	Max.	Min.
Formald.	20%	4	154	39	43	67	30	20	25	15	229	219	300	125
,,	15%	3	138	44	41	53	35	30	36	25	146	143	150	140
,,	10%	4	220	55	53	55	45	54	67	43	136	133	156	110
,,	7·5%	4	182	45	59	69	49	68	76	63	111	112	136	87
,,	5·0%	4	219	55	61	65	53	86	93	79	106	103	121	86
,,	2·5%	4	174	43	66	80	54	91	96	87	51	39	62	23

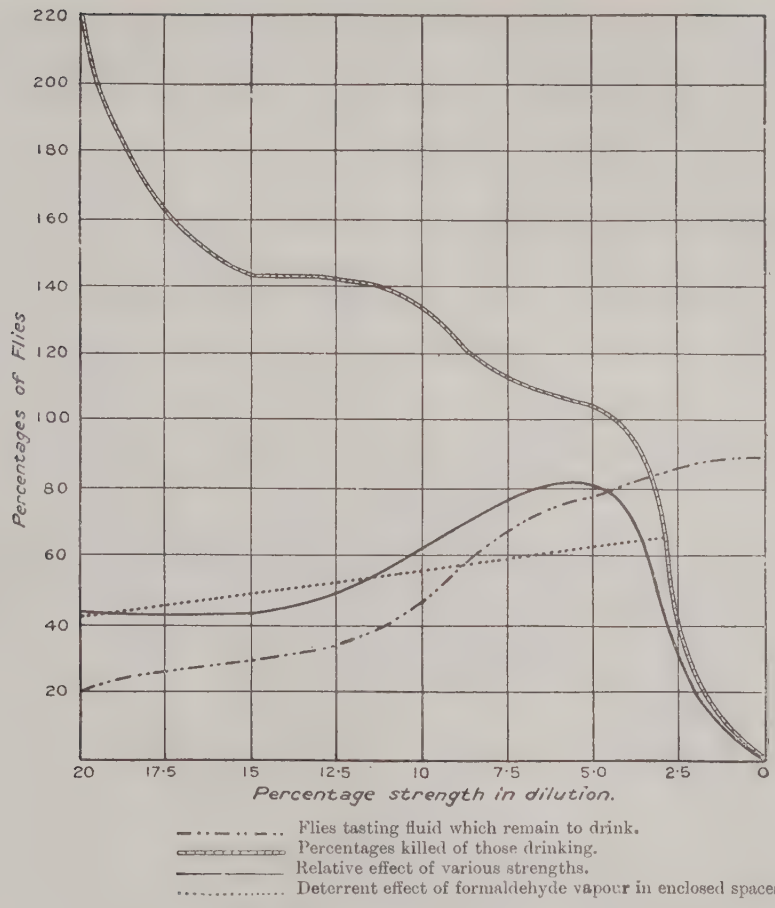


Diagram 2. Showing the most effective strength of formaldehyde.

The Optimum Concentration.

The conclusion drawn from the experiments just described was checked by the following series of further experiments. In each series concentrations of 10 per cent., 7·5 per cent., 5·0 per cent., and 2·5 per cent. formaldehyde, with 50 per cent. lime water and 2·5 per cent. sugar, were placed in saucers with blotting paper covers and these were exposed to flies in cylinders (10 in. diam., 8 in. high). Each experiment was continued for twenty-four hours, and counts were made at intervals of the flies lying inert. Seven series were completed, and about 100 flies were used in each cylinder. The summary of the whole is given in Table XIV. In this are shown the average number of flies in each cylinder, and the average percentages inert at the end of various intervals. These results are plotted in Diagram 3; the dot-and-dash line represents 2·5 per cent. formaldehyde; the continuous one 5 per cent.; the line of dashes 7·5 per cent.; the dotted line 10 per cent. Although recoveries are only

indicated in the case of 2·5 per cent., they occurred occasionally also in the case of 5 per cent. and 7·5 per cent. strengths. This method confirms the conclusion that the most effective strength to use is 5 per cent., then 7·5 per cent., then 10 per cent., while 2·5 per cent. is the least effective. The factors of effect of these concentrations had been found to be 80·3, 76·1, 62·5, and 33·5 respectively.

TABLE XIV.

Showing the Death-rate of Flies exposed to various strengths of Formaldehyde.

Formaldehyde strength	No. of tests	Av. no. flies	Av. percentages inert after :				
			1 hour	3 hours	4 hours	5 hours	24 hrs.
10%	7	81	33	45	54	58	92
7·5%	7	92	44	53	63	65	93
5·0%	7	98	51	58	64	72	96
2·5%	7	96	42	48	57	53	89

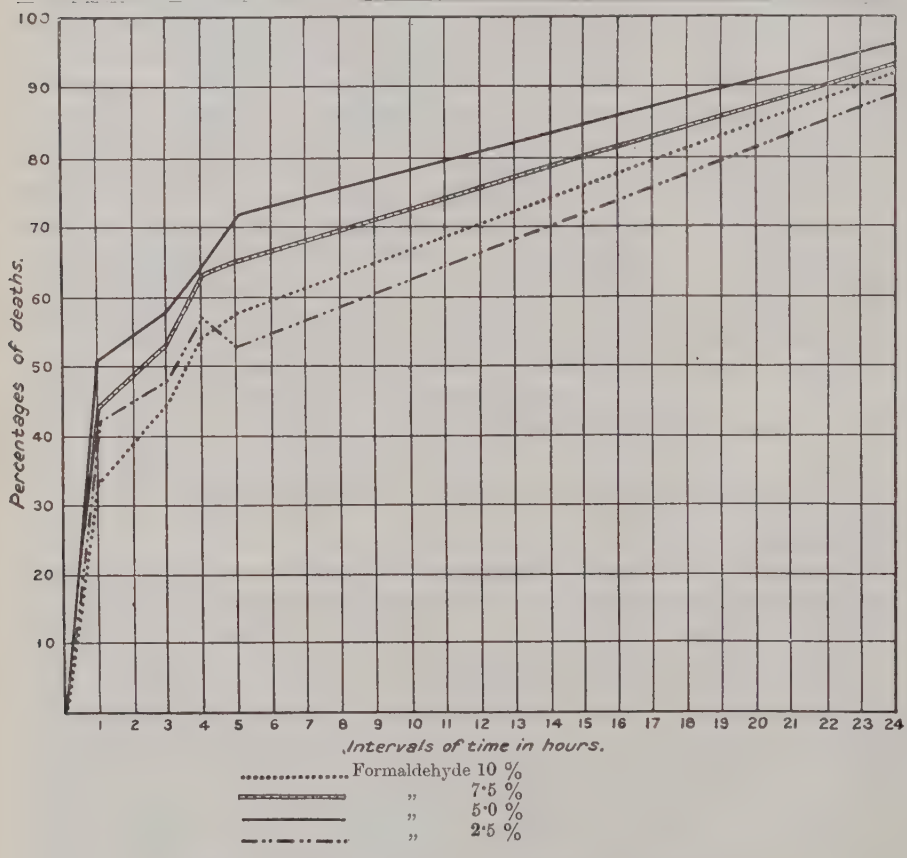


Diagram 3. Showing the relative strengths of formaldehyde.

Advantages of adding a Bait.

Reference to Table XII and to Diagram i will show that to get the best effect from the formaldehyde it is necessary to add some bait to counteract the deterrent effect. By this means a larger number of flies are induced to drink. Sugar is the most attractive and most permanent bait, and 2·5 per cent., or half an ounce to the pint, in the dilution is sufficient; to make it stronger does not make it more effective, while at 1 per cent. it begins to lose its influence. An advantage of this substance is that it has no interaction with the formaldehyde. Glucose, maltose and lactose have also been tried, but are less effective than cane sugar. Molasses will be found effective. An infusion of hay, boiled and strained, and a cold infusion of horse-dung have been tested and found to be effective, but less so than sugar, and they are not recommended for this reason.

The formula to be employed is :—

40 % Formaldehyde, 50–60 cc.	1 fluid ounce.
Filtered lime water, 500 cc.	½ pint.
Sugar, 25 grams	½ ounce (dessertspoonful).
Water, add to make 1,000 cc.	add to make 1 pint.

Method of Administration.

It is necessary to protect the formaldehyde from the action of air, and to prevent flies from falling into it, both of which factors make it acid, and soon cause the lime water to be neutralised. A simple form of trap has been devised for this. The poison is placed in a bottle, and the mouth is closed by means of a platform of absorptive material from the centre of which a stem of the same material passes down into the fluid. The top is wetted with the fluid at the commencement and is kept wet by

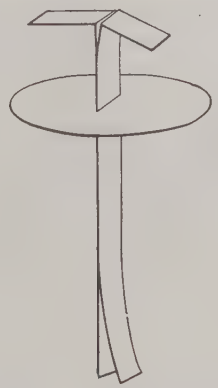


Fig. 1. Form of trap for use with formaldehyde.

capillary attraction. Such an arrangement may easily be made from blotting paper. A circle of the paper two inches in diameter is cut out, and a small slit is made in the centre. Two strips of the paper of the same width as the slit are then passed through it and the ends are doubled outwards and downwards. The strips are then drawn down till the doubled-back portions rest on the platform, and the trap is ready for use (see fig. 1).

This form of trap may be used under cover or outside when it is not raining. The paper should be renewed every third or fourth day in any case. A more permanent form may be made from plaster of Paris or some other durable material, porosity being an essential. The stem in this case is circular and should be in one piece with the top, or fit into it very tightly, otherwise the fluid will not rise. It may be necessary to soak this trap in water occasionally and dry it.

These traps have been submitted to the very severe tests of being placed near dishes of the food which has been found most attractive to house-flies, casein, banana and bread, mixed and wetted. One trap with the top made of plaster of Paris was placed about a foot away from a large dish of this material, and in three days poisoned 1800 flies, which were found on, or within a few inches of it. After further neutralisation it became effective again and remained so for ten days, about half the original fluid (200 cc.) having been used. Another one, with the top made of filter paper two inches in diameter, was placed in a corner of the fly room, and was active for ten days until it was removed, the paper top having been renewed once; 1,560 flies were found dead around it. A third one with a paper trap was still active at the end of a month. Whether a trap is still effective may be determined by sweeping away the dead flies from its vicinity. If no more flies accumulate, and there are still flies about, the fluid has probably become acid and should be renewed, as it will not be found worth while in practice to neutralise it again. The traps should be placed wherever flies are numerous, especially near rubbish bins, in stables, near manure heaps, in kitchens and latrines. Observation will show which are the best positions.

Comparison with other Poisons.

Formaldehyde as a fly poison was not tested against sodium arsenite, but it has two great advantages over it: it is safe and it is more economical. With 2 per cent. sodium arsenite solution 10 per cent. sugar is recommended, while formaldehyde only requires a quarter of that amount. The use of sodium arsenite would always be dangerous to man and to domestic animals, especially if issued to the general public. That the poison used shall be safe in any hands is a great desideratum.

The action of formaldehyde was tested against that of sodium fluoride, recently recommended as an effective fly poison (Jackson and Lefroy). Formaldehyde (5 per cent.) and sodium fluoride (1 per cent.) in saucers were placed in two separated halves of a deep glass dish, equally lighted and heated. No baits were used in either. After twenty-four hours in the formaldehyde section 650 flies were dead as against 234 dead in the sodium fluoride section. As more might have escaped from the section containing the fluoride than from the other section, a control comparison was made with cylinders of flies, four containing as poison 1 per cent. sodium fluoride with 3 per cent. sugar, and four containing the formaldehyde mixture recommended above. Notes were made of the death-rate and it was found that there was no appreciable difference in the actions of the two poisons. The results are summarised in Table XV. However from the first experiment it is seen that flies poisoned travel less from the formaldehyde than from the fluoride, which is an advantage. Authorities differ as to whether sodium fluoride is a poison to man, but as it is used in food preserving it is certainly not a very dangerous substance.

TABLE XV.

Comparing the Effects of Formaldehyde and Sodium Fluoride as Fly Poisons.

Solution.	No. of tests.	Aver. flies.	Aver. percentages dead after : 1 hour	4 hours	24 hours
1% sodium fluoride, 3% sugar	4	111	57	76	94
5% formaldehyde, 50% lime water, 3% sugar	4	74	66	74	96

Summary.

The effective action of formaldehyde as a fly poison depends on the freedom of the exposed fluid from formic acid, and, to a less extent, from methylamine. That used for fly poisoning should therefore be colourless and free from a fishy odour, and a weak alkali, in slight excess, should be added in dilution to neutralise any acid present and that which will be formed during exposure. The formula recommended is :—

40% Formaldehyde	5–6%
Clear lime water	50%
Sugar	2·5%
Water	add to make 100

This should be exposed in a trap which will protect it from the air and will prevent flies from falling in. Formaldehyde, like any other stomach poison for flies, will be most effective under dry conditions.

References.

1. O. C. Lodge, Proc. Zool. Soc. Lond., Sept. 1916.
2. Thorpe, Dictionary of Chemistry, on formaldehyde.
3. Mally, C. W. " On the use of poisoned bait for controlling the house-fly ; " S. African Journal of Science, June 1915.
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AFRICAN APHIDIDAE.—Part IV.

By Fred. V. Theobald.

The following new species of Aphids have been sent from Africa; four are from a collection forwarded by Mr. Claude Fuller of the Department of Agriculture of the Union of South Africa (*Macrosiphum cissi*, *Phorodon violae*, *Capitophorus chrysanthemi* and *Forda natalensis*); one has been sent by Mr. C. C. Gowdey from the British East African Protectorate which has to be placed in a new genus (*Cerciaphis*).

Macrosiphum cissi, sp. nov. (fig. 1).

Alate viviparous female.

Antennae longer than body, rather dark, pale at base of third segment; basal segment wider and a little longer than second; third longer than fourth, not so long as sixth, with a line of 15–18 sensoria extending nearly to the end of the segment the distal one usually markedly separated from the others; fourth segment a little longer than fifth, the latter with the usual sub-apical sensorium; sixth with long flagellum and usual sensoria at apex of basal area; fourth to sixth markedly imbricated; with short, simple, scattered hairs. Eyes large and dark. Frontal lobes small, but prominent, median ocellus prominent; head with slightly spatulate

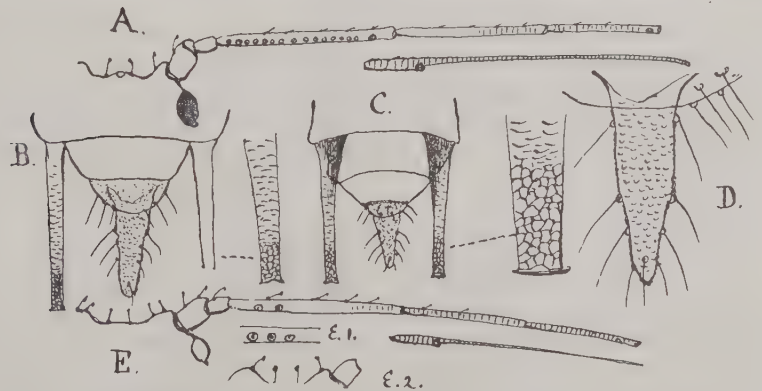

Fig 1. *Macrosiphum cissi*, sp. n.: A, head of alate ♀; B, cornicles and cauda of apterous ♀; C, cornicles and cauda of alate ♀; D, cauda of alate ♀; E, head and antenna of apterous ♀.

hairs. Proboscis rather broad, dark at apex, reaching to or just beyond the second coxae, apical segment a little longer and narrower than second. Legs long and thin, dark at apices of femora and tibiae, tarsi dark, most of hind femora dark, short hairs over apex of femora and tibiae. Cornicles black, long and cylindrical, about as long as third antennal segment, apex reticulate, remainder imbricated. Cauda about one-half the length of cornicles, pale, with three pairs of long lateral hairs, a smaller apical pair and a median sub-apical one. Anal plate darker and with many hairs. Cauda not quite level with apices of cornicles. Wings normal. *Length*, 2–2–3 mm.

Apterous viviparous female.

Antennae longer than body ; first to third segments pale, except apex of latter, remainder dark ; first segment much larger than second ; third longer than fourth, but shorter than sixth, with a group of 2–6 sensoria near the base ; fourth longer than fifth, the latter with usual sub-apical sensorium, both combined a little shorter than sixth to about the same length ; flagellum of sixth long ; hairs normal. Head with well formed frontal lobes and with a small median prominence showing only in some specimens ; other mounted specimens show the vertex almost flat. Eyes large and dark. Proboscis reaching to or just beyond the second coxae ; apical segment longer and considerably narrower than the penultimate. Cornicles dark, cylindrical, somewhat expanding basally, reticulate at apex, remainder imbricated ; shorter than third antennal segment. Cauda pale, about half as long as cornicles and slightly thicker, with three hairs on each side and some apical ones ; not quite reaching the apices of the cornicles. Legs relatively shorter and thicker than in alate female : apices of femora and tibiae and tarsi darkened ; hairs moderate. Anal plate dusky, with rather long hairs. Hairs of body slightly spatulate. *Length* 2·2–2·5 mm.

Nymph.

Antennae longer than body ; darkened on fifth and sixth segments ; basal segment larger than second ; third longer than fourth ; fourth longer than fifth ; the sixth much longer than 4+5 ; flagellum long, but relatively shorter than in mature forms ; a few scattered hairs. Proboscis with dark apical segment, reaching to the third coxae ; last two segments nearly equal. Wing pads dusky ; cornicles dark ; about as long and as thick as third antennal segment, imbricated ; reaching past the cauda. Cauda triangulate, pale, with two pairs of lateral hairs. Legs with dusky apices to tibiae, but not to femora ; latter with hairs on one side ; tibiae hairy. *Length* 1·8 to 2 mm.

Food-plant. Cissus sp.

Transvaal : Pretoria 18.x.1918.

Described from three alate females and a number of apterous females and nymphae. No colour notes were sent, but the species is so well marked that I have described it. It comes nearest to *Macrosiphum*, but also approaches *Myzus*, especially in the alate stage. Mounted apterae show the vertex in different forms, some have it almost flat, others of typical *Macrosiphum* form, whilst others show a median prominence. In the various larval instars the differences are great ; the first has very short thick cornicles, in later stages they increase in length. The length of the cornicles varies in the adults.

The plant upon which these Aphids were found—*Cissus*—is one of the Order Ampelideae. This genus is often merged into *Vitis*. None of the species recorded from *Vitis* agrees with Mr. Fuller's specimens, and so far no Aphid has been recorded from *Cissus*.

The Aphids recorded from *Vitis* are *Aphis illinoisensis*, Shimer ; *Aphis ripariae*, Oestlund ; *Aphis vitis*, Scopoli ; *Macrosiphum viticola*, Thomas ; *Hyalopterus arundinis*, Fabricius ; *Perityмbia vitisana*, Westwood ; *Rhizoctonus ampelinus*, Mokrzeki ; *Schizoneura ampelorhiza*, Del Guercio ; and three species of *Phylloxera*.

Rhopalosiphum carduellinum, Theobald (fig. 2).

Bull. Ent. Res. vi, p. 112. figs. 9 and 10, (1915).

Apterous viviparous female.

Antennae about as long as the body, arising from prominent frontal tubercles ; basal segment much larger than second ; third not quite as long as the sixth, with 17–20 small sensoria along one side ; fourth slightly longer than fifth, with 3–6 sensoria ; fifth with normal sub-apical sensorium ; sixth about as long as 4+5, its basal area about one-fourth the length of the fifth ; the apices of segments 3–5 are darkened and there is a dark area at junction of basal area and flagellum of sixth ; all the segments are imbricated ; the sensoria on 3 are of varied size and shape ;

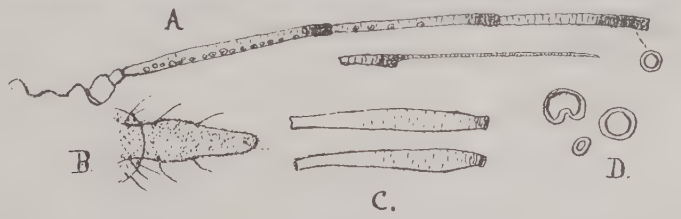

Fig. 2. *Rhopalosiphum carduellinum,* Theob., apterous female ; A, head and antenna ; B, cauda and anal plate ; C, cornicles ; D, sensoria on 3rd antennal segment.

those on 5 are more regular in outline. Proboscis reaching to just past the second pair of legs ; two bands of a few hairs on penultimate segment ; two marked sub-apical ones on the apical arising from clear circular areas. Legs with apices of femora and tibiae darkened and dark tarsi, a few hairs on apex of femora and numerous short ones on the tibiae. Cornicles about as long as the fourth antennal segment, about twice as wide and somewhat swollen on the apical half ; apex with a few striae, remainder faintly imbricated. Cauda pale, broader than cornicles, more than half their length, with three long hairs on each side and a curved sub-apical one ; reaching just beyond the apices of cornicles. *Length,* 1·8–2 mm.

Food-plant. Thistles (*Carduus* sp.).

Transvaal : Pretoria, 20.v.1914 (*C. Fuller*) ; Onderstepoort, 28. vii. 1914 (*G. B. Bedford*).

Type in the British Museum.

The apterous female sent with the alatae of this insect appears to be a distinct species. The sensoria in the two apterous females sent by Mr. Claude Fuller appear so much more closely allied that I have little doubt that they are true *carduellinum.*

Numbers of nymphae sent were mostly all of a uniform pale colour, evidently yellow or green, but a few show the tips of the wing pads dusky. One of the sensoria on the third antennal segment is markedly bean-shaped, and the varied size of the others is somewhat characteristic.

Phorodon violae, sp. nov. (fig. 3).

Apterous viviparous female.

Yellowish green to dull pale yellow. Antennae longer than body, of same colour as body except extreme tip of fifth and whole of sixth segments, which are dark ;

basal segments (1 and 2) somewhat darker than the rest ; the basal one much larger than second and somewhat projecting on its inner side ; third segment longer than fourth, but not so long as sixth ; fourth and fifth about equal in length ; flagellum moderately long, about as long as third ; a few scattered hairs over the segment and the third with short stiff hairs arising from small projections along one side, some extending on to the fourth ; basal segment imbricated. Frontal lobes large, with

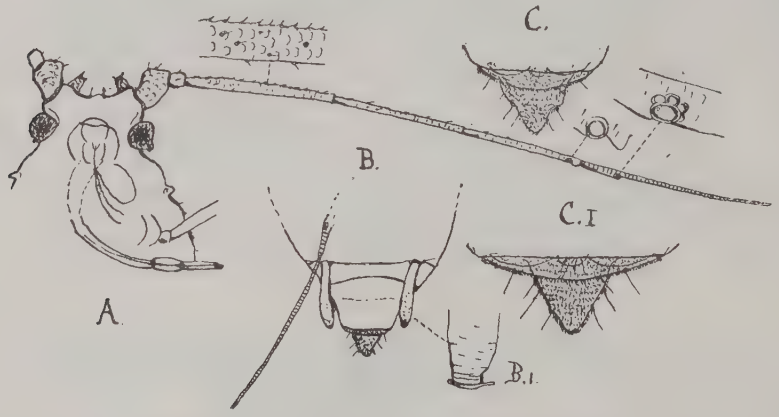

Fig. 3. *Phorodon violae*, sp. n., apterous viviparous female : A, head of apterous ♀ ; B, posterior end of body and end of antenna ; B. 1, cornicle ; C, C.1, cauda.

a marked, slightly inwardly directed, cone-like process on each side, imbricated and with two minute hairs. Two stiff hairs also project from the vertex. Eyes large, red to dark red. Proboscis pale, apex slightly darkened ; reaching to or just beyond the third coxae, narrow ; apical segment a little narrower and longer than penultimate. Legs of same colour as body, except the tarsi which are darkened ; very short stiff hairs on the tibiae. Cornicles of same colour as body, moderately long, but shorter than the fourth antennal segment, slightly swollen from the middle onwards ; faintly imbricated, sometimes slightly expanded at the base. Cauda pale, short, bluntly triangulate, spinose, with two short hairs on each side ; projecting well beyond the cornicles. Anal plate slightly darkened, narrow, spinose, with four long apical hairs and others somewhat shorter. On each side of pronotum a small lateral papilla and traces of four others on each side of the abdomen. The body is contracted at the apex. *Length*, 1·3–1·8 mm.

Nymph.

Colour similar to adult. Antennae about as long as body and of same colour ; sixth segment and apex of fifth dusky ; basal segment much larger than second, third a little longer than fourth ; fourth and fifth about equal ; sixth as long as or a little longer than 4+5, its basal area about half the length of the fifth. Frontal processes as in alate female. Eyes bright red. Wing-cases of same colour as body, also the legs, except apices of tibiae and the tarsi, which are smoky, with numerous fine short hairs. Cornicles and cauda pale, the latter bluntly triangulate and

extending beyond the cornicles, which are shorter than the fifth antennal segment. Cauda finely spinose, but showing no lateral hairs. The pale proboscis reaches nearly to third coxae. *Length*, 1·2–1·5 mm.

Food-plant. Pansy.

NATAL: Durban, 1.x.1912.

Described from a number of apterous females and some nymphae. Nearly all the females have the posterior portion of the gut, etc., evaginated, giving them a curious ragged appearance. The shape of the body is also marked.

I have placed this species provisionally in the genus *Phorodon* on account of the two marked frontal processes and the swelling on the basal segment of the antennae, but the cornicles and cauda do not exactly fit in with that genus, taking *P. humuli*, Schrank, as the type. The flattened anal plate occurs, however, in some stages of the hop aphid.

Capitophorus chrysanthemi, sp. nov. (fig. 4).

Apterous viviparous female.

Apparently a pale green or yellow species, with black eyes; dusky apices to the cornicles and antennae; tarsi all dark and to some extent the apices of the tibiae; hairs capitate. Antennae longer than body; basal segment larger than second and somewhat angulated on the inner side; third segment much longer than fourth

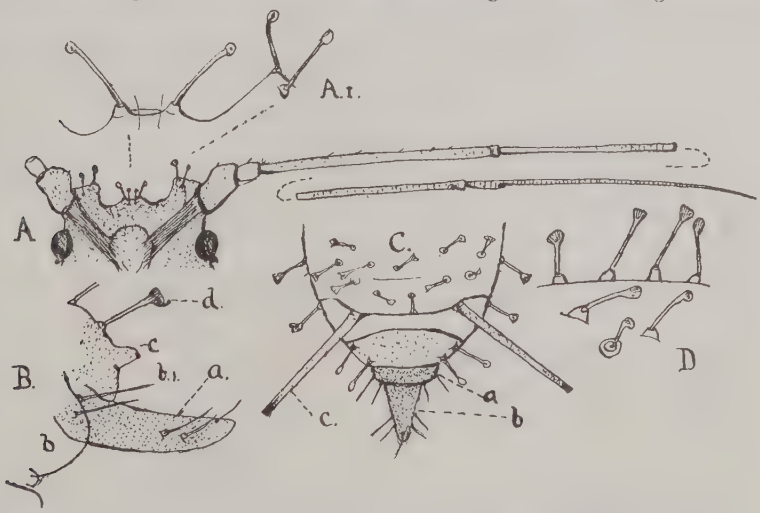

Fig. 4. *Capitophorus chrysanthemi*, sp. n.: A, head of apterous ♀; A. 1, enlarged cephalic hairs; B, anal region; *a*, cauda; *b*, anal plate; *b*. 1, hairs of anal plate; *c*, dorsal process; *d*, body hairs.

but not so long as the sixth; fourth a little longer than fifth, the latter with the usual sub-apical sensorium; sixth with long flagellum, basal area about one-fourth of the fifth segment. Head with marked frontal lobes and a median raised process; with two capitate hairs on each lobe, two in front on the median lobe, and two just above them. Eyes prominent, varying from black to deep red or reddish black. Proboscis pale, reaching to just past the second coxae; apical segment

narrow and acuminate, penultimate nearly as long, expanded. Legs pallid, except tarsi, which are dusky except at extreme base; tibiae with moderately long fine hairs and a few on apex of femora. Cornicles long and very thin, about as long as fourth antennal segment; pale, apex dark. Cauda pale, rather long and thick, bluntly elongate-triangular, with two hairs on each side, close together towards the apex and a median sub-apical one; finely spinose. Anal plate slightly darker, spinose and with a few long hairs, broadly rounded. The thin cornicles project to about the level of the cauda, which is very much wider and about half to less than half their length. Body hairs strongly capitate, some with fan-shaped extremities, whilst those on the anal plate and cauda are simple. The lateral view shows a small tubercle above the cauda (fig. 4, B. *c.*). *Length*, 1·8–2 mm.

Food-plant. Chrysanthemum.

Orange Free State: Bloemfontein, 18.v.1914.

Described from several mature apterous females. It resembles a typical *Myzus*, but the median frontal projection places it in Van der Goot's genus *Capitophorus*; which appears to be undoubtedly well marked, but I find so many species between the true *Myzus* and typical *Capitophorus* that it is doubtful if this genus should be accepted, unless many others are to be initiated.

Genus **Cerciaphis,** nov.

Described from apterous viviparous females.

Head flat to very slightly concave in front. Antennae shorter than body, of five segments, the third about as long as 4+5; the fifth longer than fourth, its flagellum only half the length of basal area. Eyes small. Cornicles small, cone-shaped. Two thick, acuminate anal cerci, about as long as fourth segment of antennae. Cauda small, flattened. Anal plate rounded. Proboscis rather short.

Cerciaphis bougainvilleae, sp. nov. (fig. 5).

Apterous viviparous female.

Pale-coloured; apices of antennae dusky. Eyes small and dark. Legs, cornicles, anal plate, cauda and base of antennae of same colour as body. Head narrower

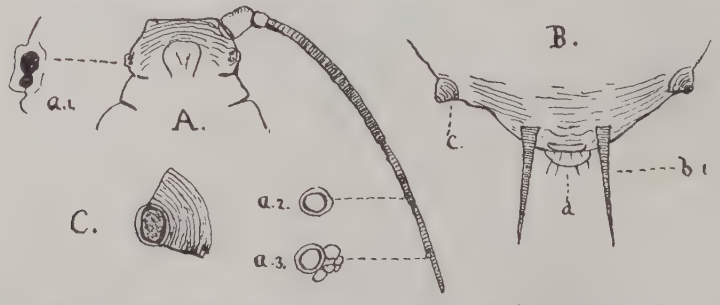

Fig .5 *Cerciaphis bouganvilleae*, sp. n.: A, head of apterous ♀; *a.* 1, enlarged eye; *a.* 2, and *a.* 3, sensoria; B, posterior end; *b.* 1, cerci; *c*, cornicle; *d*, cauda and anal plate; C, cornicle.

than body, which is more or less oval; head flattened to slightly concave in front. integument strongly striate. Antennae shorter than body, of five segments, the

basal one larger than second, the third the longest, as long as or longer than 4+5 ; the fourth shorter than fifth, with a simple round sub-apical sensorium ; the fifth with the flagellum short, about half the length of the basal area, which is equal in length to the fourth segment ; third to fifth imbricated. Cornicles cone-shaped, of Lachnid appearance, more or less circularly striate. Two long, pale, acuminate anal cerci, striate and about the length of the fourth antennal segment to a little longer. Anal plate pale, small, with a few longish hairs. Cauda inconspicuous. Legs rather short and thick. The posterior integument is striate, but not so markedly as the cephalic. The proboscis in all the mounted specimens is bent forwards but appears to reach to about the second coxae. *Length*, 1·4–1·8 mm.

Food-plant. Bougainvillea.

Uganda : Kampala, 14.v.1919 (*C. Gowdey*).

Described from a number of apterous viviparous females. It is a very marked insect on account of the two posterior cerci. The head and body seem almost devoid of hairs, except posteriorly. The nymphae have long narrow wing-buds.

Forda natalensis, sp. nov. (Fig. 6).

Apterous viviparous female.

Globular, much domed dorsally, flattened ventrally. Grey, greyish white to brown ; antennae, proboscis and legs brown. Segmentation marked posteriorly. Antennae from one-fourth to one-fifth the length of body ; of five segments, basal one about half the length of second, third the longest, about as long as 4+5 ; fourth shorter

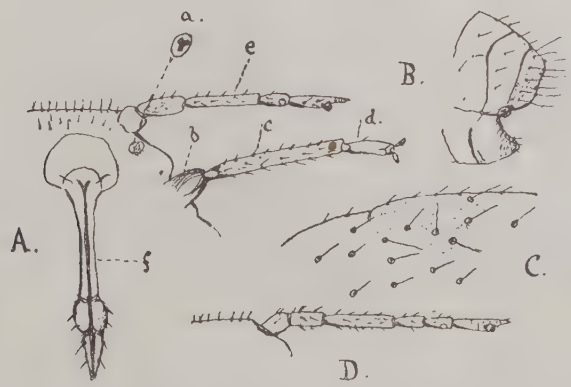

Fig. 6. *Forda natalensis*, sp. n. : A, head ; B, cauda, C, integument of apterous viviparous ♀ ; D, nymph.

than fifth ; fifth with a short blunt nail, a large rather projecting sensorium at its base and traces of a secondary one, also a round sensorium at the apex of the fourth ; slightly hairy ; last two segments darker than remainder. Vertex flat, with a few short blunt hairs. Eyes very small, black. Proboscis reaching to near the third pair of legs or just past them, moderately broad ; apical segment a little longer and narrower than the penultimate, with a few short hairs. Legs rather short and thick, prothoracic shorter than mesothoracic, the latter shorter than the

metathoracic ; tibiae and tarsi with short fine hairs, a few on the femora ; femora of first and second pairs nearly as long as tibiae, the third a little shorter. Body with short fine scattered hairs, except at the apex, where they are longer. *Length*, 2–2·5 mm.

Immature viviparous female.

Paler, legs pale brown ; antennae dark on last two segments only. Antennae about one-fifth the length of the body ; basal segment shorter than second and very little broader ; third a little longer than second ; fourth about as long as the first ; fifth a little shorter than third, with a small blunt nail, with normal sensoria at its base ; a few scattered hairs. Proboscis reaching to or beyond the third pair of legs. Legs short, just projecting beyond the body, the first slightly shorter than second, third the longest ; tibiae and tarsi with hairs as in adult. Eyes very small. Body with a few rather short scattered hairs. *Length*, 1·5–2·0 mm.

Food-plant. Roots of a weed and in ants nest.

Natal : Umzinto, 23.iv.1911.

Described from several apterous viviparous females and some immature forms. It somewhat resembles *Forda rotunda*, Theobald, but can at once be distinguished by the long second antennal segment and the short fourth segment, also by the flat vertex and different posterior structure. The eyes also do not project in the same way, and the body is clothed with scattered fine short hairs.

Some specimens show a partial constriction on the third antennal segment, but I could find none in which it was complete, so that they are only of five segments.

Species not previously recorded or from new Localities.

Macrosiphum dahliafolii, Theobald, Bull. Ent. Res. vii, p. 273, 1918.

Uganda : Kampala, 2.xii.1917 (*Gowdey*) ; on thistles (*Carduus*).

Macrosiphum sonchi, Linnaeus. Syst. Nat. ii, p. 735.

Uganda : Kampala, 2.xii.1917 (*Gowdey*) ; on thistles (*Carduus*).

One apterous ♀, which agrees with British specimens. The darkening of the antennae around the sensoria of the third antennal segment is very marked.

ANOPHELES BREEDING AMONG WATER LETTUCE—A NEW HABITAT.

By James Zetek, B.A.,

Entomologist, Ancon, Panama Canal Zone.

With the filling up of Gatun and Mira Flores Lakes, water lettuce (*Pistia stratiotes*, Linné) and water hyacinth (*Eichornia crassipes*, Solms.) rapidly increased in numbers until large areas became completely covered by them. Masses of these plants would become detached and float about in these lakes. It was found necessary to destroy these "floating islands," not because they were serious mosquito habitats, but because they interfered with navigation and the operation of the spillways. The water lettuce is the habitat of the very specialised larvae of *Mansonia*, of which *titillans* is the commonest member. Knab (1913) and Busck (comments appended to Mr. Knab's paper) refer to the changes in the mosquito fauna brought about by the rapid increase in *Pistia*. Both *Mansonia titillans*. Walker, and *Aëdomyia squamipennis* (Lynch-Arrib.) Theo., have been collected by me in very large numbers since 1912, and to-day *Mansonia* is the dominant species caught in the army barracks on the west side of the canal. Knab expressed the opinion that perhaps measures would have to be taken to destroy the *Pistia* habitats; now that we have found *Anopheles* larvae in them, this prophesy comes closer home.

The only question involved is how much of a menace are these floating islands to our towns. It is my belief they are a menace to the towns on the west side of the canal, and if allowed to float toward Paraiso and Pedro Miguel, or close to Gatun, would be a source of danger there. It has been shown conclusively that our common malarial *Anopheles* do fly more than a mile (Zetek, 1915); in fact, it appears that they will fly as far as they must in order to get food. Should Las Cascades become a negro settlement, the dangers from malaria would be increased. I doubt if we can depend upon screening and mosquito-catching indoors to control the *Anopheles* and malaria at such a settlement. At any rate, the idea seems to be getting firmly established that the sanitation of the Panama Canal Zone is so efficient that there is virtually little danger from the *Anopheles*, and as a result our people are becoming somewhat negligent. It will depend mainly upon the cumulative evidence gathered by the District Sanitary Inspectors, whether or not these floating islands will need to be controlled.

That this evidence may be available and accurate, it is very necessary that the sanitary inspectors make it their practise to take ample field notes. These should contain as complete a statement of the particular habitat, date and locality added thereto, and specimens of the larvae should be sent to the laboratory for the accurate determination of the species. At the close of each month a general summary of these notes should be made, a copy of which should be sent to the entomologist. It is a regrettable fact that much valuable information is lost or buried in the heads of observers.

In 1918 I found *Anopheles* larvae among water lettuce at Juan Mina, a citrus plantation about five miles up the old Chagres River. On 21st November 1919, Messrs. Picket and Tolar, sanitary inspectors at Pedro Miguel, Dr. D. P. Curry,

Assistant Chief Health Officer, and I, made an inspection of floating islands at Gamboa, C. Z., both in the canal prism and across in the bayous ; we went as far as Empire. Mr. Pickett previously reported the presence of *Anopheles* larvae in these islands at this place, and that they were going southward toward his station. Our joint inspection revealed larvae of *Anopheles albimanus*, Wied., and *A. tarsimaculatus*, Goeldi, to be plentiful among the leaves of the water lettuce. An unidentified *Culex* was also present.

This particular habitat is very favourable to the *Anopheles*. The larvae are afforded much protection from the schools of young fish that usually feed upon insect larvae. They are also protected to some extent from predaceous insect larvae, such as those of dragon-flies. Shade is another important factor in this habitat, and this means a more even temperature, and an almost total absence of the direct hot rays of the sun. Wave action does not disturb these larvae very much ; but the most important advantage to them is the exceptionally favourable presence of oxygen, and this certainly must be effective in prolonging the life of the larvae and pupae. This factor is very easily explained. The *Pistia*, being a green plant, gives off oxygen. Its leaves are at or just above or below the surface of the water. Therefore this oxygen enriches the local atmosphere available to the larvae, and some of it is undoubtedly taken up by the water and made use of by the larvae through their cutaneous respiration.

During the summer of 1911, while engaged by Dr. S. A. Forbes to study the *Anopheles* at Havana, Illinois, a similar condition was found to exist, excepting that in place of *Pistia* the plant in question was the tiny *Lemna*. This plant covered the surface of the water in the bayous, ponds and quiet recesses of the rivers. The Chatagua grounds at Havana were invaded each year by *Anopheles*, but their source was not known until we found them in and among the floating islands of this *Lemna*. These islands broke away from the almost continuous mass across the river from Havana and by current and wind were swept across this deep body of water and came to rest along the shores of the Chatagua grounds ; here the larvae developed, pupae formed and adults emerged in rapid succession.

There is one important aspect of this sort of habitat which must not be overlooked. It is that wind and current detach portions of this floating vegetation and sweep it across deep bodies of water to new localities, where were it not for this exceptionally good vehicle these larvae would be unable to cross the barrier of deep water.

Searching through the literature available at our laboratory, I find that Ingram and Macfie (1917) found larvae of *Anopheles costalis*, Lw., and *A. marshalli*, Theo., in exactly the same sort of habitat, composed of the same species of *Pistia*, at Christiansborg, near Accra, West Africa. Associated with them were : *Aëdomyia africana*, Nev.-Lem., *Mimomyia splendens*, Theo., *Culex quasigelidus*, Theo., and *Mansonioides africanus*, Theo.

In a previous paper, in which he discusses the limitations of kerosene as a larvicide, Macfie (1917) states (p. 278) that *Mansonioides africanus* flies over one mile and that its breeding places can be located with fair accuracy, inasmuch as they are composed of *Pistia*. On page 278 he states it is useless to hope for a total abolition of such mosquitos by ordinary oiling, and that a layer of kerosene (p. 294), no matter

how thick, applied to the surface of the water in which larvae of *M. africanus* live is absolutely innocuous. He is right, and this is corroborated by our observations upon *Mansonia titillans*, which is our counterpart to his *M. africanus*. But nowhere in this article, nor in the preceding one, does he touch upon the control of the *Anopheles* which live in this same habitat, nor does he refer to the use of emulsions which mix with the water and kill by contact, or the destruction of the *Pistia* by means of sodium arsenite or their removal by boats.

The logical control is to destroy the habitat. This may be costly and prolonged, and perhaps prohibitive where large numbers of bayous, ponds, cut-offs, etc., exist. If *Anopheles* alone are to be controlled, spraying with a phenol-resin soap emulsion every six days will probably be all that is necessary. It may even be effective against the *Mansonia*.

Macfie (1917) goes into great detail in his discussion of the favourable oxygen factor in this *Pistia* habitat and relates experiments made with certain mosquito larvae which corroborate his contentions. That this exchange of gases is a favourable one is quite certain. Our common *Anopheles* have been known to stay on the bottom for five minutes; if through the presence of green plants they have a more favourable habitat, then it follows that not only may cutaneous respiration be much more prolonged, but the general death-rate among the larvae may be greatly reduced. This death-rate is reduced also because the leaves of the plants protect the larvae from the numerous swimming enemies in the water, and from the hot, direct rays of the tropical sun.

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LIST OF THE ANOPHELINES OF THE MALAY ARCHIPELAGO WITH SPECIAL REFERENCE TO ADULTS AND LARVAE OF NEW OR INCOMPLETELY DESCRIBED SPECIES OR VARIETIES.

By N. H. Swellengrebel, Ph.D. and J. M. H. Swellengrebel de Graaf.

The following species and varieties have been found in the Malay Archipelago* :—

Myzomyia: ludlowi, rossii, vaga (indefinita), flava, minima, minima var. aconita.

Neomyzomyia: leucosphyra, punctulata var. tesselata.

Cellia: kochi.

Myzorhynchus: sinensis, sinensis var. vanus and var. separatus, barbirostris, barbirostris var. pallidus, albotaeniatus, mauritianus, umbrosus, gigas.

Nyssorhynchus: fuliginosus, maculatus, schüffneri, karwari, jamesi, annulipes var. moluccensis.

Stethomyia: aitkenii, aitkenii var. insulae-florum and var. papuae.

Comparison with the neighbouring Malay Peninsula shows the Anopheline fauna to be almost identical in the two countries. The exceptions are :— *M. aurirostris*, *P. watsoni*, *M. sinensis* var. *peditaeniatus*, *M. albotaeniatus* var. *montanus*, *M. pseudumbrosus*, *M. hunteri* and *L. asiatica*, which are not found in the Archipelago; whereas the Peninsula lacks *M. mauritianus*, *M. gigas*, *M. barbirostris* var. *pallidus*, *S. aitkenii* var. *insulae-florum* and var. *papuae*, and *N. annulipes* var. *moluccensis*.

I.—Description of New Species and Varieties.

1. **Myzomyia immaculata,** Theo.

Myzomyia flava, Swellengrebel (1917).†

A yellow mosquito, with light orange-coloured unbanded legs, creamy unbanded palpi, brownish yellow proboscis and creamy wing scales. Wings unspotted.

♀. Head scaled like *M. rossii*, on the occiput broadly expanding upright forked scales, all scales creamy. Palpi unbanded, creamy. Proboscis brownish yellow, labella yellow. *Thorax*: prothoracic lobes with brownish yellow hairs. Mesonotum with hair-like scales, narrow curved ones in front and a few at the sides, all scales creamy. Scutellum with dark yellow hairs and creamy hair-like scales. Halteres

* Contrary to the present custom we adhere (with a few exceptions) to Theobald's nomenclature, not because we attach to his "genera" any intrinsic value as indicating a really existing relationship, but because the division of the Anophelines into genera is a practical measure, expressing the idea present in the mind of every one who studies these insects in nature, that, *e.g.*, *M. sinensis* is quite distinct from *M. aconita*, but closely allied to *M. barbirostris*, and that *S. aitkenii* is something apart from all other Anophelines. By calling all these species "*Anopheles*" one simply causes confusion and not simplification.

† [On a recent visit to England Dr. Swellengrebel presented to the British Museum a ♂ and ♀ of his *Myzomyia flava*. On comparing the latter with the type of Theobald's *A. immaculatus* both he and Mr. F. W. Edwards concluded that they were conspecific. The older name *immaculatus* must therefore be used for this interesting and little known form.—Ed.]

creamy, light brown at the curve. *Abdomen* with golden hairs, narrow curved golden scales on genital lobes. *Legs* unbanded, light orange. Ungues equal and simple. *Wings* unspotted; scales narrow, creamy or light yellow. Base of 1st submarginal cell nearer the wing base than that of 2nd posterior; the cell is longer than its stem, 2nd posterior cell shorter than its stem. Supernumerary and anterior cross-veins meeting, the posterior one more than twice its length from the latter; 3rd longitudinal vein not ending at the meeting of the supernumerary and anterior cross-veins. *Length,* 4–5 mm.

♂. Like ♀. Club-shaped end of palpi yellow, owing to the presence of long yellow hairs mixed with the creamy scales; a dark narrow band caused by partial desquamation. Narrow-curved creamy scales on the two apical abdominal segments. On the wing, anterior cross-vein situated basally from the supernumerary. *Larva* unknown.

JAVA: Soerabaia. SUMATRA: Mandailing.

Rare. Described from 3 ♀♀ and 3 ♂♂ taken at Soerabaia, June 1917. Easily distinguished from other unspotted Anophelines by the long palps (*M. brevipalpis*) and the broadly expanding upright forked scales on the head (*S. aitkenii*). The species may perhaps be an albinoid variety of *M. vaga* (*indefinita*), as this species sometimes shows a marked decrease of the black portions on the wings and palpi.

2. **Nyssorhynchus annulipes** var. **moluccensis,** Swell. (1920).

A rather large brown mosquito, with spotted legs, 4-5 light bands on palpi, the apex of the 2nd joint being black; proboscis dark, except labella; narrow curved scales on the whole dorsal surface of the mesonotum; wings much spotted, resembling those of *N. punctulata* var. *tesselata.*

♀. *Head* scaled as in other *Nyssorhynchi.* Antennae light brown, basal segment with small white scales, verticils and tomentum golden. Proboscis dark brown,

Fig. 1. Palpi of *Nyssorhynchus annulipes* var. *moluccensis* ♀, three variations.

labella lighter. Palpi (fig. 1): 1st joint black with creamy apex and sometimes a dorsal yellow spot in the middle; 2nd joint black, with a broad white band on apical half and a narrow yellow one at the apex, sometimes a yellow dorsal spot in the middle of the black basal portion, the sub-apical white band sometimes narrow or even absent; penultimate and terminal joints with a narrow black basal band, then a narrow yellow band, the remaining portion creamy. *Thorax*: prothoracic lobes blackish brown, with black chaetae and a tuft of black scales in front. Mesonotum with a dark spot to the right and left at one-third from the anterior border and one in front of scutellum, covered all over with narrow curved white scales,

which also are present on scutellum. Pleurae dark, with a few narrow curved white scales. Metanotum light brown, with a dark median line. Halteres white, with the knob dark at the apex. *Abdomen* dark brown; on apex of 6th and 7th segments narrow curved golden scales, on 8th black ones likewise. *Legs* dark brown with white spots, many of them forming incomplete rings; 1st tarsal joint banded apically, 2nd–4th at both ends (except in hind legs, which have an apical band only); 5th banded at both ends in front legs, unbanded in the others, in front and mid-legs this joint is white on one side. A sub-apical elongated light spot on the tibiae of front legs. Coxae yellowish brown, with narrow white scales. *Wings* (fig. 2):

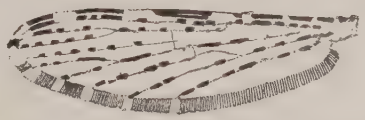

Fig. 2. Wing of *N. annulipes* var. *moluccensis*, ♀.

on the costa from base to apex 3 short and 4 long black spots and a short one between the 1st and 2nd long spots, these last three extending on to the sub-costa. The 1st–4th long costal spots extend on to the 1st longitudinal in the form of 2, 3–4, 3–4, small spots and one long one; moreover a small spot below the interval of the 1st and 2nd and the 2nd and 3rd costal long spots, and 1–3 at the base. Other small spots are present as follows:—3–5 on upper branch, 5–7 on lower branch, 2–4 on stem of 2nd vein; 5–6 on 3rd vein; 2 apically, one longer basally on upper branch, 2–3 on lower branch of 4th vein, on its stem below the cross-veins a long one, above them 2 long or 1 long and 2 short ones; 4 on the upper branch and lower one, 3 on the stem of the 5th vein; 5–6 on the 6th vein. Fringe dark with bright incisions at the tips of the veins and upward from the 3rd longitudinal vein, except a narrow black spot between the branches of the 2nd vein. Length of 1st submarginal cell more than twice that of stem, its base situated basally from that of 2nd posterior cell. Supernumerary and anterior cross-veins almost meeting, posterior one twice its length from anterior.

Length, 4–5·5 mm.

♂. Palpi: 1st joint black, mixed with white on one side; articulation with 2nd joint light, owing to absence of scales; 2nd joint with one side of basal half and top white, the latter white portion fringed with yellow. Club-shaped end white, black on one side, with basal and median black ring, separated from the white by a yellow margin. *Length* 5–6 mm.

Moluccas. New Guinea.

Described from 5♀♀ and 3♂♂.

Larva (fig. 3). Length 5 mm. Colour greenish brown or dark greyish-green; head brown, with dark bands and spots; white spots on thorax in front and on abdominal segments iii and vii or iii and vi-viii. Antennae without branched hair. Median clypeal hairs far apart, with a few short hairs; external clypeal hairs often nearly as long as medians, with long hairs; posterior clypeal hairs as far apart as medians, reaching to the base of the latter, unbranched or with 2–3 branches.

External occipital hairs with 4 branches, internal ones with 3 branches or simple. A pair of small fans* on thorax, with 10–14 leaflets, sometimes pigmented, no serrate margin. Small fans on abdominal segment i, with 8–16 leaflets, usually serrate, not pigmented. Complete fans on segments ii-vii, with about 18 leaflets, pigmented, serrate near the tip, the latter long and pointed, sometimes ending in a true filament. Shoulder hairs † with thick stem and numerous branches; median and internal one with stout roots which often unite into one.

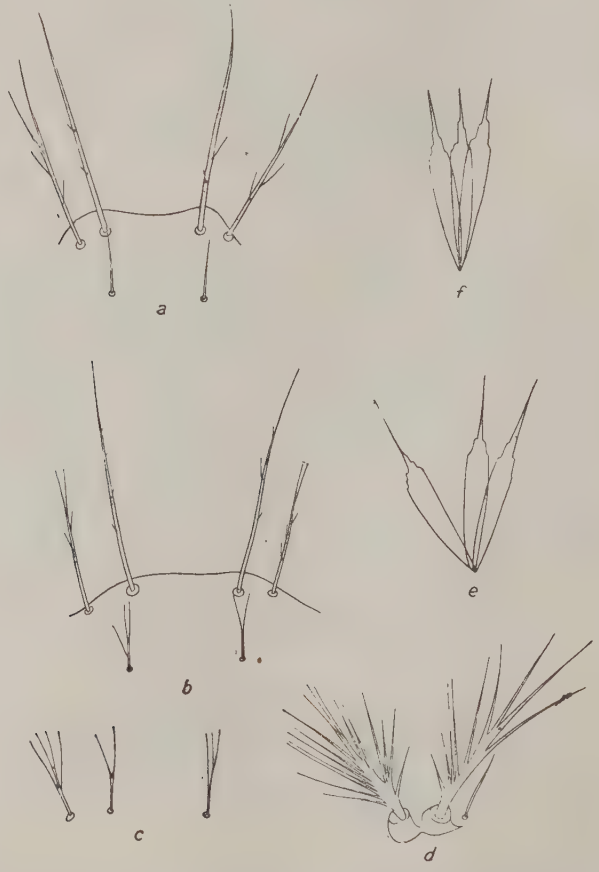

Fig. 3. Larva of *N. annulipes* var. *moluccensis*: *a*, *b*, two types of clypeal hairs; *c*, occipital hairs; *d*, shoulder hairs (right); *e*, *f*, leaflets.

Breeds in all kinds of water, brackish or salt and fresh, running and stagnant, clean and dirty; also in artificial collections of water (coconut-shells, water in native boats).

* Fan = stellate tuft.
† Shoulder hairs = anterior thoracic hairs.

This variety much resembles *N. annulipes*, Walker, as described by Theobald, but the female palpi are different in the latter, the apical half of the 2nd joint being all white. Also, there is a marked likeness to *N. punctulata*, Dön., but the proboscis of this species has a light apical half and the black apical ring of the 2nd palpal joint is much narrower.

3. **Stethomyia aitkenii** var. **insulae-florum,** Swell. (1920).

The imago is not to be distinguished from *S. aitkenii*.

Larva (fig. 4). Length 5 mm. Colour dark green. Antenna with small branched hair. Median clypeal hairs close together, simple, nude; external clypeal hairs simple, nude, length $\frac{1}{3}$ of median ones; posterior clypeal hairs far apart, short, with 3–6 branches; occipital hairs with 3–6 branches. Shoulder hairs with only the median one inserted on a strong root, carrying about 11 branches, the internal one with about 8. Small fans on thorax and abdominal segment i, carrying 13–15

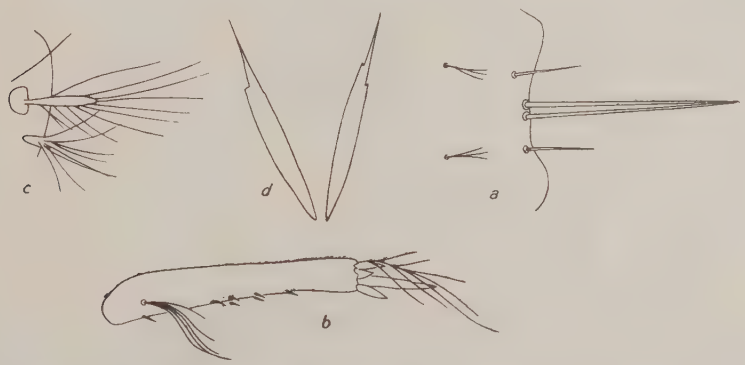

Fig. 4. Larva of *Stethomyia aitkenii* var. *insulae-florum*: *a*, clypeus; *b*, antenna; *c*, shoulder hairs (left); *d*, leaflets.

non-serrate leaflets; segments ii-vii with complete fans, the leaflets very indistinctly serrate, ending in a long point, no filaments.

Breeds in running water in the weeds along the edges, in hilly regions. With the variety *papuae* it is the only representative of this species in the Australian region of the Archipelago. Only once has it been found in Java (Island of Noesa Kembangan on the South Coast).

The larva is somewhat like that of *S. culiciformis*, James, but the club-shaped antennal hair is wanting and the balancing hairs on abdominal segments i-iii are of the usual type and number.

4. **Stethomyia aitkenii** var. **papuae,** Swell. (1920).

Although no adults could be bred from this larval variety, we feel sure that it likewise belongs to this species. It much resembles the larvae of the preceding variety, but is separated from it by the fact of the internal shoulder hairs being very small and carrying two branches only. The leaflets of all the fans show no signs of serration.

The larvae described here, were full-grown, the pupal hairs already showing through the integument of the 1st abdominal segment.

Breeds in the same places as the foregoing variety, but was only found in New Guinea (Kokas, Kaimana, May 1919).

4. **Myzorhynchus barbirostris** var. **pallidus,** nov.

Adult like *M. barbirostris.*

The relation of this variety to its type is the same as that of *M. peditaeniatus,* Leic., to *M. sinensis,* viz., the larvae differ from the typical ones by the external clypeal hairs bearing a smaller number of branches (11–22 against 60 or more in the type) (fig. 5).

Fig. 5. Larva of *Myzorhynchus barbirostris* var. *pallidus,* right half of clypeus.

Breeds in slowly running water, in springs in the jungle and in rice-fields, but always in hilly country. It is rare in Java and Sumatra ; in the Australian portion of the Archipelago it is as common as the typical form.

II. Larvae of known Species not yet or incompletely described.

1. **Myzorhynchus albotaeniatus** (fig. 6).

Length 5–5·5 mm. Colour dark rusty brown, lighter on dorsum of 3rd abdominal segment, less conspicuously so on the 6th, the 4th almost black. Antennae more stumpy than in *M. sinensis,* length : breadth : : 1 : 4 (1 : 5 in *sinensis*) ; a branched hair on antennae, its stem half the length of the hair (in *sinensis* $\frac{1}{6}$–$\frac{1}{7}$), the branches emitted nearly at right angles (in *sinensis* at very sharp angles). Median clypeal pairs simple, nude, the distance between them equal to that separating them from the external clypeal hairs (close together in *sinensis*) ; external clypeal hairs with 18–24 terminal branches; posterior clypeal hairs short, with 3 branches ; occipital hairs with 6–7 branches. Internal shoulder hair very small, with 2–3 short apical branches. Small fans with 12–16 non-serrate leaflets on thorax and abdominal segments i-ii ; complete fans on segments iii-vii ; leaflets as in *M. sinensis.*

Breeds in slowly running jungle streams with scanty vegetation but much vegetable detritus. Java and Sumatra.

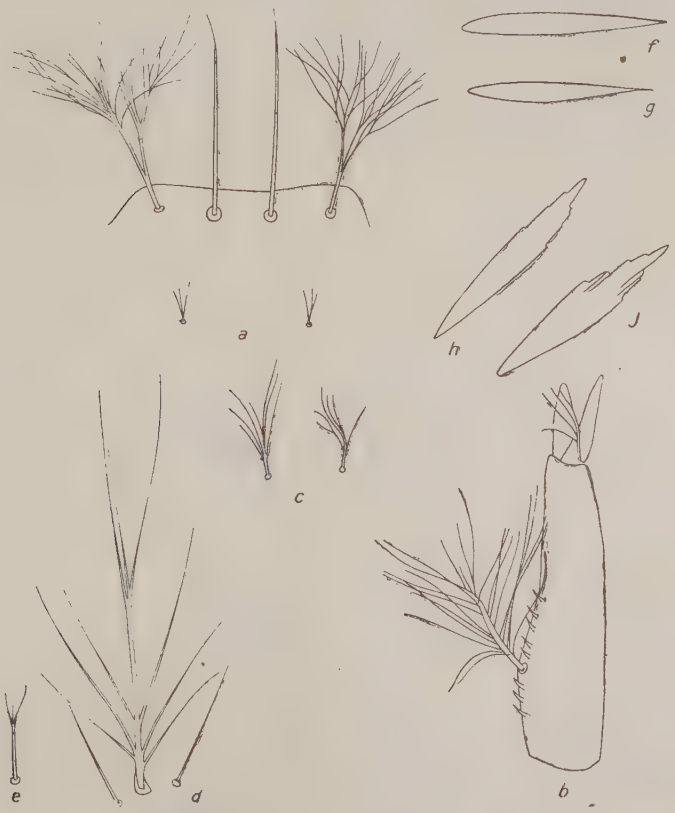

Fig. 6. Larva of *Myzorhynchus albotaeniatus*: *a*, clypeus; *b*, antenna; *c*, occipital hairs; *d*, shoulder hairs (right); *e*, variation of inner shoulder hair; *f*, leaflet, thoracic fan; *g*, leaflet, fan on abdominal segment i; *h*, leaflet, segment iv; *j*, leaflet, segment v.

2. **Neomyzomyia leucosphyra** (fig. 7).

As our own observations differ from those of Stanton (1915) the larva is redescribed here.

Length 4·5–5·5 mm. Colour light yellowish brown or brownish grey. Antennae without branched hair. Median clypeal hairs long and slender, simple, sometimes carrying a few minute hairs; external clypeal hairs nude and simple; posterior ones short, nude, simple; occipital hairs with 2–3 branches. Shoulder hairs usually pigmented, median and internal ones with strong stems, numerous branches and stout roots, often uniting into one. Small fans on thorax, with 10–11 non-serrate leaflets. On abdominal segment i very small fans with 5–7 hair-like leaflets;

on segment ii small fans with 8–11 very narrow leaflets ; on segments iii-vii complete fans with about 18 leaflets each, showing 2–3 indentations near the apex, the latter pointed or rounded, no filament. The leaflets are pigmented throughout.

Breeds in stagnant shady freshwater pools.

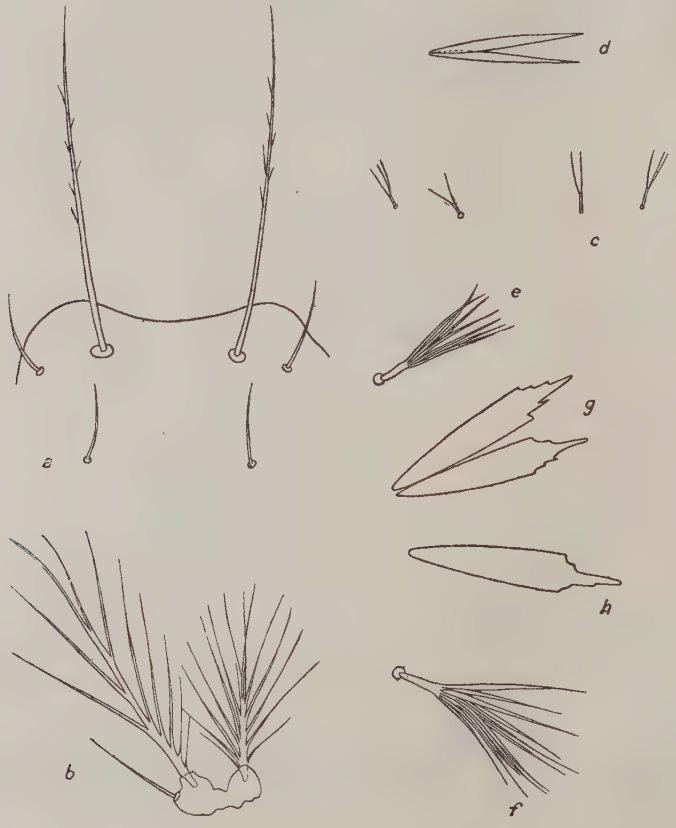

Fig. 7. Larva of *Neomyzomyia leucosphyra* : *a*, clypeus ; *b*, shoulder hairs (left) ; *c*, occipital hairs ; *d*, leaflet of thoracic fan ; *e*, leaflet of fan on abd. segment i ; *f*, leaflet on segment ii ; *g*, leaflet on segment iii ; *h*, leaflet on segment v.

3. **Myzorhynchus umbrosus.**

Addition to Stanton's description. Another larval type was usually met with in salt or brackish water near the coast, with median clypeal hairs bearing numerous short hairs on the apical half. The adult emerging from this was of the usual *umbrosus* type.

4. **Myzomyia minima** var. **aconita** (fig. 8).

Addition to Stanton's description : In running water a larval type was common with completely nude median and simple long posterior clypeal hairs. The adult emerging from this larval variety showed the usual characteristics of *aconita*. The breeding places of the two larval types differ somewhat : out of 644 typical larvae 42 per cent. were found in rice fields, 11 per cent. in running water, 31 per cent. in fish-ponds, 15 per cent. in marshes and 1 per cent. in dirty stagnant water ; the percentages of 562 specimens of the larval variety found in the same breeding-places were 1·7, 88, 10, 0·3 per cent. and nil. Consequently the latter is more adapted to life in running water.

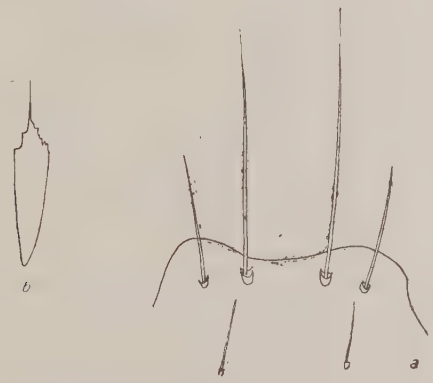

Fig. 8. *Myzomyia minima* var. *aconita*, larval variety : *a*, clypeus ; *b*, leaflet of fan on abdominal segment v.

It is to be noted that the larva of the typical *M. minima* (fig. 9) is almost identical with the larval variety of *aconita*, the only difference we could detect existing in the length of the filaments of the leaflets which is $\frac{1}{2}$ -$\frac{3}{8}$ of that of the whole leaflet (in the larval variety of *aconita* this relation is usually $\frac{3}{10}$—$\frac{2}{5}$).

5. **Differences between the Larvae of Nyssorhynchus punctulata var. tesselata and Cellia kochi.**

Stanton enumerates them as follows : In *N. punctulata* there are no fans on abdominal segments i and ii, whereas in *C. kochi* they are present on the latter. We noted in both species on segments i and ii small fans with very narrow or hair-like leaflets ; in *C. kochi* on segment i sometimes a cockade only. Consequently in the Malay Archipelago the fans cannot be used to distinguish these larvae. We use the following characters : In *N. punctulata* : (*a*) Antennae usually much pigmented ; (*b*) occipital hairs short with 3 or more branches ; (*c*) internal shoulder hairs short, usually with no more than 3 apical branches.

In *C. kochi* : (*a*) Antennae light ; (*b*) occipital hairs longer, unbranched or bifurcated ; (*c*) internal shoulder hairs long, with numerous long branches inserted at intervals along the stem.

In the Australian region of the Malay Archipelago, a larval variety of *N. punctulata* is commonly met with, bearing fans with non-serrate leaflets, no fans but cockades on the 2nd abdominal segment, and a small fan with hair-like leaflets on the 1st.

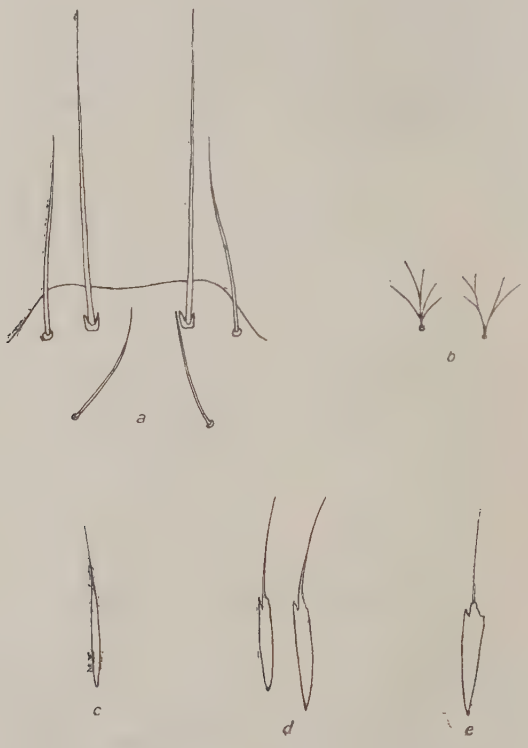

Fig. 9. Larva of *Myzomyia minima*: *a*, clypeus; *b*, occipital hairs (left); *c*, leaflet from fan on abdominal segment i; *d*, leaflet on segment iii; *e*, leaflet on segment vi.

6. **Difference between the Larvae of Myzorhynchus sinensis and M. barbirostris.**

In addition to Stanton's differential characters we noted the following, which however cannot be used if the larvae do not show white spots on the dorsum of the abdomen. But if these are present, they show in *M. sinensis* on abdominal segments iii, v, viii, in *M. barbirostris* on the segments iii and vi–viii but never on v. *N. annulipes* var. *moluccensis* has abdominal spots like *M. barbirostris*.

7. **Abnormal Larvae of Myzorhynchus sinensis and M. barbirostris** (fig.10).

In both species one of the median clypeal hairs may be placed in close proximity to the neighbouring external clypeal hair, at the same time exhibiting on a shortened

stem a number of long apical branches (10 or more), somewhat resembling the external clypeal hairs of *M. umbrosus*.

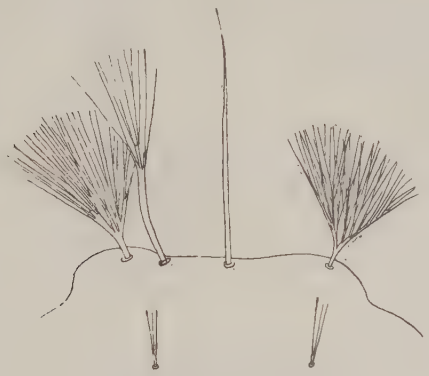

Fig. 10. Abnormal clypeus of larva of *Myzorhynchus sinensis*.

8. **Variations in the larvae of Myzomyia ludlowi and M. rossii.**

As yet we have not succeeded in differentiating these species ; in both we have noted the following variations of the mature forms : (*a*) The posterior clypeal hairs are of normal length and bifurcated, or much shorter and trifurcated ; (*b*) the median clypeal hairs are bifurcated ; (*c*) all clypeal hairs bear 2–5 long apical branches.

These variations are infinitely more common in *M. rossii* than in *M. ludlowi*. Sometimes we found *M. rossii* emerging from larvae resembling those of *M. vaga* (*indefinita*).

9. **Variations of the Larvae of Myzomyia vaga (indefinita).**

We never found *M. vaga* with larvae like *M. ludlowi*, they always adhere to the type first described by Strickland (1915), *viz.*, with the short external and posterior clypeal hairs, the latter placed at a short distance behind the median clypeal hairs and closer together than these. As variations we have noted the bifurcation of the median and posterior clypeal hairs, the latter being placed farther backwards ; also they may be placed close together, the one a little in front of the other.

10. **Nyssorhynchus schüffneri** (fig. 11).

The larva was described by Mangkoe Winoto (1918). They are difficult to distinguish from those of *N. fuliginosus*. The following are the characters which separate them : (*a*) the median clypeal hairs bear more and longer branches ; (*b*) the posterior clypeal hairs are unbranched or bifid ; (*c*) the stems and roots are less thick than in *N. fuliginosus* ; (*d*) the filaments of the leaflets on the fans are somewhat shorter than in the same organs of *N. fuliginosus*.

Fig. 11. Larva of *Nyssorhynchus schüffneri* : *a*, clypeus ; *b*, leaflet of fan on abdominal segment v.

III. Questions concerning the Validity, Definition and Nomenclature of some Species.

1. **Nyssorhynchus fuliginosus var. nivipes.**

This variety is characterised by the following points : (*a*) the white area on 2nd joint of the hind tarsus is very extensive, $\frac{1}{3}$–$\frac{1}{2}$ of the joi. (*b*) wing much lighter, with smaller spots, notably on 3rd vein and upper branch of 5th. The same wing markings are present in the male of the typical *N. fuliginosus*, consequently they cannot be used to separate the males of the type and the variety.

2. **Myzomyia minima, and var. aconita.**

Christophers (1916) separates these two forms on the grounds that the type (*a*) has the proboscis in the ♀ dark, or with only a light ventral spot near the apex ; (*b*) lacks a light fringe spot at the apex of the 6th vein ; (*c*) has the apical half of the 6th vein completely dark ; (*d*) has a long black spot on the base of the 3rd vein. To this we may add that (*e*) the type shows a broad black band on the middle of the light apex of the palps (in *aconita* this band is narrow). The two forms seem well separated by these characters, but we have met with otherwise typical *aconita* exhibiting the points (*b*) and (*c*), or (*a*), or (*b*) (*c*) (*e*). Moreover, we have found forms with the points (*b*) and (*c*) complete and (*a*), (*d*), (*e*) intermediate ; *i.e.*, with a large light patch on the proboscis but ventrally only, a small black patch on the base of the 3rd vein and a band on the apex of the palps in breadth intermediate between that of *minima* and *aconita*. On the other hand, we have observed specimens bearing a spot on the base of the 3rd vein at least equalling in length $\frac{1}{2}$ of the stem of the 1st submarginal cell, but with all the other *minima* characters present likewise.

As we do not think it advisable to throw these two forms together, we propose a purely artificial but easily observable distinction, viz. :—

(*a*) No spot on base of 3rd vein .. .. *M. aconita*, Dön.

(*b*) A small spot present (length about ¼ of the 1st submarginal cell), *M. aconita* var. *cohaesa*, Dön.

(*c*) A long spot present (from half as long to as long as this cell).. *minima*, Theo.

3. Myzomyia vaga (indefinita).

The species known under the name of *M. indefinita*, Ludl. (1904) is separated from *M. rossii* by (*a*) a narrow black band at the base of the light apex of the female palpi ; (*b*) a light spot at the apex of the proboscis in the female, behind the labella ; (*c*) a lighter colour ; (*d*) its larger size ; (*e*) the larva. The points (*a*), (*c*) and (*d*) are subject to great variation, (*b*) and (*e*) being constant and reliable ; as (*b*) is not present in the males and (*a*) only refers to the females, the males cannot be distinguished with certainty.

In 1902 Dönitz described under the name *A. vagus* a mosquito distinct from although resembling *M. rossii*. The proboscis of the female is described as being black, with light apex and whitish labella. The palpi of the female are black, the terminal joints white, the penultimate with a broad black band around the base. A distinct variety from Celebes has the penultimate joint of the female palpus white only at the apex. As this is the condition actually existing in *M. rossii* we infer that the specimen on which the species *vagus* was founded had a narrower black palpal band. The species was described from a female caught at Fort de Koch (Sumatra) and we know that no *M. rossii* has ever been found there. From the description of the proboscis and palps of the female (in connection with the description of the variety from Celebes) and the origin of the type we believe that there can hardly be any doubt that Dönitz's *vagus* and the species now called *A. indefinitus* are identical.

Christophers (1916) suggests that Giles' *M. rossii* might be the one with the broad white apex of the palps. As Giles (1900) states that the apical half of the end joint (*i.e.*, of the two terminal joints taken together) is white in the female, we believe this supposition to be not well founded. On the other hand we believe him to be quite right in suggesting that Ludlow's *indefinita* is indeed *M. rossii*, Giles, as she distinctly states (1904) that the palpal markings and general colour of her new species are like those of *M. ludlowi*.

4. Difference between Myzomyia ludlowi and M. rossii.

The following wing marking is very constant and reliable : on the upper branch of the 5th vein, below the cross-veins, both species show two spots, which however in *M. rossii* (and *M. vaga*) are short, whereas in *M. ludlowi* they are much longer. An extensive biometrical research has convinced us that exceptions to this rule are rare (Swellengrebel 1916, Mangkoe Winoto 1918).

5. Neomyzomyia punctulata and N. tesselata (A. deceptor, Dön.).

One of us has shown already that the characters differentiating these two species, so far as they are based on the wing markings, cannot be accepted as valid. Consequently the species are separated only by the palpal markings : in *N. tesselata*

the second palpal joint of the female is white on the apical half, in *N. punctulata* it bears a black sub-apical ring, separated however by a narrow light ring from the basal black ring of the 3rd joint. We do not consider this difference of sufficient value to justify a new species and consequently we rank *N. tesselata* as a variety of *N. punctulata*.

Dönitz believed the var. *tesselata* to be peculiar to the western regions of the Malay Archipelago only, but we have found it as far eastward as Ceram (Moluccas). Dönitz's typical *punctulata* we have never met with. The eastern *punctulata* var. *tesselata* differs however from the common western type, (*a*) by the larvae (p. 7.), (*b*) by the light portion of the proboscis being distinctly diminished in size.

6. **Nyssorhynchus schüffneri.**

Christophers (1916) seems to suggest that this species resembles *N. fuliginosus* var. *adiei*, James. It is said to differ from it by the very short ultimate joint of the female palpus. We found the length of this joint to be 11 per cent. of the palpal length, the palpal index being 0·6, consequently it is an orthodactylous mosquito. But there are other, more striking differences. The palps have 3 white bands only (4 in *adiei*), with a long white tip resembling *M. vaga*. The wing, which in the var. *adiei* is like that in *N. fuliginosus* (judging by James' description), is much lighter in *schüffneri*; the black spots on the costa are rather narrow, on 2nd longitudinal vein one small spot under the 3rd costal spot (reckoned from the apex). Stem of 4th longitudinal vein nearly all yellow, so is the 3rd vein (in *adiei* it is black, except for a few minute light spots).

IV. Geographical Distribution.

A considerable portion of the Malay Archipelago has been searched for Anophelines, and although much remains to be done, we wish to draw attention to the following striking features in the geographical distribution of certain species and varieties.

1. **Nyssorhynchus annulipes var. moluccensis.**

Wherever it occurs this is a very common species, breeding everywhere, and so it is difficult to overlook it. Still it has never been found in Sumatra, Java, Borneo, Celebes and the smaller islands of the western portion of the Archipelago, but it is the commonest Anopheline in the Moluccas and New Guinea. It is closely allied to the Australian *N. annulipes* and its distribution is in accordance with other zoological findings, showing the fauna of the eastern Archipelago to be mainly Australian. It is well known that Wallace divided the Archipelago into an Asiatic and an Australian region by a line following the Straits of Macassar and of Lombok. The Anophelines (and with them other animals; *cf.* Weber 1902) do not conform to this scheme, as the Anopheline fauna of Celebes, so far as we know at present, is purely Asiatic.

2. **Nyssorhynchus schüffneri.**

So far as we yet know, this species is confined to the western provinces of Java (Batavia, Bantam) and the neighbouring Lampong districts of South Sumatra, which are separated from the former by the Soenda Strait.

3. Myzomyia rossii.

Christophers (1916) states that *M. rossii*, Giles, is the common western form, whilst *M. vaga*, Dön. (*indefinita*, Ludl.) occurs throughout Malaya. To this should be added that *M. rossii* does so likewise, as far as the Moluccas; only in Sumatra it has not been found, up till now.

4. Myzomyia ludlowi and Myzorhynchus sinensis.

We failed to find both species east of Celebes. But we know that in districts where *M. ludlowi* usually is of common occurrence, it may be absent for months and even for a whole year (Citroen 1917). As suitable breeding places were present, likewise its common satellite *M. rossii*, we are not sure that *M. ludlowi* is really absent from the Australian regions of the Archipelago.

5. Stethomyia aitkenii

The form with the typical larvae—including all variations described by Stanton (1915) and Strickland (1915)—was not found in the Australian region of the Archipelago. The species was represented there by the varieties *insulae-florum* and *papuae*, which in their turn were absent from the western regions, except var. *insulae-florum*, which occurs on the south coast of Java (Island of Nocsa Kembangan).

The following table gives a summary of our present knowledge of the distribution of the Anophelines in the Malay Archipelago.

	javanensis	*minima*	*aconitus*	*rossii*	*ludlowi*	*vaga (indefinita)*	*punctulata* var. *fea.*	*leucosphyra*	*koliensis*	*sinensis* (all varieties)	*barbirostris*	*barbirostris* var. *pallidus*	*albotaeniatus*	*marvitiatus*	*umbrosus*	*gigas*	*fuliginosus*	*maculatus*	*schüffneri*	*hackeri*	*annulipes* var. *moluccensis*	*farauti*	*aitkenii*	*aitkenii* (Varieties)	*brevipalpus*
Sumatra	+	+	+	—	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	—	—	+	—	—
Java	+	—	+	+	+	+	+	+	+	+	+	+	+	+	+	—	+	+	+	—	—	+	+	+	—
Borneo, incl. findings of Roper (1914) ..	—	—	+	+	+	+	+	+	+	+	+	—	+	—	+	—	—	+	—	—	—	—	—	—	+
Celebes	—	—	—	+	+	+	+	+	—	+	+	—	—	—	—							—			
Moluccas and New Guinea	—	—	—	+	—	+	+	—	—	—	+	+	—	—	—	—	—	—	—	—	+	—	—	+	—
Riouw and Linga Archipelagos ..	—	—	—	—	+	—	—	—	+	+	+	—	—	—	+	—	—	+	—	+	—	—	+	—	—

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COLLECTIONS RECEIVED.

The under-mentioned collections were received by the Imperial Bureau of Entomology between 1st January and 31st March, 1920, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Dr. J. H. Ashworth, F.R.S. :—2 Chironomidae, 16 Culicidae, 6 *Tabanus*, and 17 *Glossina* ; from the Sudan.

Surg.-Comm. E. L. Atkinson :—4 *Tabanus* and 3 larvae of *Musca domestica*.

Mr. E. Ballard, Government Entomologist :—46 Culicidae, 478 other Diptera, 28 Coleoptera, and 47 Rhynchota ; from Madras.

Capt. P. J. Barraud :—49 Culicidae, 29 other Diptera, 8 Hymenoptera, 377 Coleoptera, 36 Lepidoptera, and 45 Rhynchota ; from Palestine.

Mr. G. E. Bodkin, Government Economic Biologist :—6 Tabanidae, 37 other Diptera, 350 Hymenoptera, 34 Coleoptera, 100 Isoptera, 1 species of Coccidae, 51 other Rhynchota, 52 Spiders, 3 Centipedes, and 2 Millipedes ; from British Guiana.

Mr. P. A. Buxton :—14 Trypetidae, 5 Weevils from Cotton, and 1 Bug ; from Mesopotamia.

Mr. J. B. Corporaal, Entomologist to the Algemeen Proefstation :—136 Rhynchota ; from Sumatra.

Division of Entomology, Pretoria :—14 Diptera, 189 Hymenoptera, and 7 Coleoptera ; from South Africa.

Government Entomologist, Sudan :—3 Diptera, 11 Hymenoptera, 10 Lepidoptera, and 5 Rhynchota ; from the Anglo-Egyptian Sudan.

Mr. G. F. Hill, Entomologist, Australian Institute of Tropical Medicine :—125 Culicidae, 13 Tabanidae, 24 other Diptera, 10 Termites, and 5 species of Coccidae ; from Queensland.

Imperial Department of Agriculture, West Indies :—2 Nests of the Wasp, *Polistes annularis* and 6 Moths bred from them ; from Barbados.

Dr. A. Ingram :—87 Culicidae, 1 *Tabanus*, 2 *Glossina*, 15 other Diptera, 1 Moth, 1 Cockroach, and 2 May-flies ; from the Gold Coast.

Mr. Nigel K. Jardine :—73 Parasitic Hymenoptera ; from Ceylon.

Mr. Ll. Lloyd :—Collections of the Tomato Moth, *Polia oleracea*, L., and the Aleurodid, *Asterochiton vaporariorum*, Westw ; from Hertfordshire.

Mr. A. Loveridge, Curator, East Africa and Uganda Natural History Society :—27 Culicidae, 30 Tabanidae, 20 *Glossina*, 344 other Diptera, 37 Dipterous pupa cases, 834 Ants and 37 pupa cases, 6 other Hymenoptera, 1 Caddis-fly, 1 species of Coccidae, 1,497 other Rhynchota, 2 Orthoptera, and 228 Odonata ; from British East Africa and Tanganyika Territory.

Mrs. W. Smith :—66 Culicidae, 6 *Tabanus*, 1 *Glossina*, 50 other Diptera, 21 Hymenoptera, 23 Coleoptera, 2 Lepidoptera, 2 Caddis-flies, 41 Rhynchota, 6 Orthoptera, and 1 Tick ; from the Gold Coast.

Mr. F. V. Theobald :—2 Chalcids (*Pteromalus egregius*, Först.), bred from the Brown-tail Moth ; from Romney, Kent.

Mr. Robert Veitch :—4 Diptera, 2 Hymenoptera, 3 Coleoptera, and 21 Lepidoptera ; from Fiji.

Mr. Morris N. Watt :—7 Agromyzid Diptera ; from New Zealand.

Wellcome Bureau of Scientific Research :—9 Culicidae, 39 Tabanidae, 1 Hippoboscid, and 23 other Diptera ; from Macedonia and Africa.

Mr. C. B. Williams :—17 Scolytidae ; from Trinidad.

Mr. Rodney C. Wood :—4 Tabanidae, 1 Hippoboscid, 77 other Diptera, 165 Coleoptera, and 2 Rhynchota ; from Nyasaland.

OBSERVATIONS ON COTTON THRIPS IN THE GEZIRA, BLUE NILE PROVINCE, SUDAN, IN 1918–19.

By G. H. Corbett, B.Sc.

From conversations that the writer has had, it would appear that this thrips (identified by Mr. R. S. Bagnall as *Heliothrips indicus*, Bagn.) has been known on the Gezira cotton for about three years, and is popularly called " dry asal " in contradistinction to the work of the " asal fly " (*Aphis sorghi*, Theo.) The natives have been acquainted with this insect for some time. The reason suggested for the enormous damage done by it is that the cotton is too scattered, and it is stated that if cotton were cultivated in larger blocks, the thrips might be viewed with equanimity.

The cotton land at Barakat for this year (1919–20) has been, as far as possible, prepared in larger areas, and it will be interesting to compare the result of this arrangement with cultivation at Tayiba, where no alteration in grouping has taken place.

Towards the end of October 1918 the thrips attracted serious attention ; by the middle of November the cotton looked " all withered up," but by the middle of December it began to recover. It was not until the beginning of February that work on this insect was commenced—most of it being done in the field whilst preparing a laboratory to conduct experiments under more immediate control. At that time the cotton had practically recovered, in spite of the fact that the thrips was present in large numbers.

In most cases the infested cotton was first noticed on the north side of a " hosa," and this implies that the thrips either came from weeds growing on fallow land on that side, or was brought from a distance by the prevailing wind, and finding cotton and conditions favourable, propagated to such an extent that the immediate study of the bionomics and control of this insect was considered necessary.

The occurrence of this minute insect in enormous numbers caused, during the season 1918–19, a considerable reduction in the yield of cotton, and it must at present be viewed as a great menace to cotton cultivation in the Sudan, though it may prove to be quite local in its attack and occur only spasmodically. In any case, at a very conservative estimate, an average loss of one and a half kantars of cotton per feddan has occurred during the past season on well supervised and cultivated land.

This is the most important pest with which the cultivators of cotton in the Gezira have to contend. On account of its smallness, the rapidity of its spread, and the seeming suddenness of its attack in large numbers, the control of the insect is one which might present very great difficulties. If the thrips is found on cotton when young, it is probably practicable as well as economical to spray ; but on the other hand, if it comes suddenly when the cotton plants are about five months old, the writer considers the policy of spraying doubtful.

The injury caused to the cotton plant is due to the larvae and adults feeding on both the upper and lower surfaces of the leaves. By piercing the epidermis of the leaf and removing the sap, they lower the vitality of the plant. At the points of attack spots are formed which, often running together, produce distinct white streaks

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where the chlorophyll has been removed ; and later, if feeding is continued, the lower surfaces of the leaves acquire a silvery appearance. As the feeding of this insect is prolonged, the leaves become brownish and tough, owing to the efforts of the plant to repair the injury. In severe infestations the leaves wither up and fall to the ground, preventing the young bolls from developing.

Leaves frequently present a distorted appearance, curling inwards, and in the folds the larvae are often abundant. Larvae have been observed neither on the bolls nor in the flowers, but are occasionally seen on the bracts. On plants grown in the laboratory, larvae have been noticed feeding on the stem and root just beneath the surface of the soil. This undoubtedly was due to the leaves drying up and the thrips migrating for food. In no case was the larval stage completed in such situations.

Though this insect was first observed as attacking fully-grown cotton trees, it may be mentioned that the youngest cotton plants are not immune. For egg-laying, preference is shown by the adults for the lower leaves, and then the middle leaves. On young succulent leaves at the upper portion of the plant, the thrips are never so abundant as they are on the much eaten and tough lower leaves.

Habits of the Adult.

The usual mode of progression of the adult is walking, though when disturbed it runs, and frequently takes long quick jumps. Flight has been observed in a number of cases, but this is not general. Emerging from the pupae in the ground, the adult crawls up the stem to the leaves. In breeding cages it has been noticed to climb up the side of the chimney, and when on a level with the leaves to take a leap to the plant ; this motion is aided by the wings.

By far the larger number of the adult thrips feed on and lay their eggs in the tissue of the lower surface of the leaf, and confine their attention for the most part to the lower and then the middle leaves of the plant. Flowers seem to be immune from attack, but larvae have been found on the bracts. Very often the adults are found resting and feeding along the veins of the leaves, but, as a rule, no particular part of the leaf is preferred.

Adults enclosed in vials with plugs of cottonwool die rapidly, but under more natural conditions they have lived for a maximum of fifteen days, though the average works out at five days. The males and females emerge from the pupae about the same time, but there are indications that the pupal stage is slightly longer in the males than in the females.

The female is capable of laying eggs on the second day after emergence. On an average, six eggs each day are laid in the tissue of any part of the leaf, but though eggs have not been observed, the hatching larvae are more usually found along the veins.

Habits of the Larva.

The young larva, on hatching, looks like a starchy-coloured segmented worm, with red eyes and with no indications of legs or antennae. Gradually it works itself out of the leaf by a slight swaying motion, and standing as it were on its anal segment, unfolds antennae and legs. Later, bringing its legs to the leaf surface, it pulls itself free.

Sometimes it moves only two or three centimetres, but at other times greater distances, before commencing to feed. As it imbibes the sap of the plant, the body takes on a yellowish hue, and usually by the second day the reddish bands, so very characteristic of all stages except the adult, begin to develop. Only one moult has been observed—the change from the larva to the prepupa in the soil.

Like the adult, the larva feeds by piercing and sucking the juices of the plant. It prefers the lower surface of the leaf, though it does not by any means confine itself there. Movement from one surface of the leaf to the other is common, but from one leaf to another is exceptional. Larvae are often found segregated along the veins of the leaf, and occasionally in colonies on other parts of the leaf.

Like many species of thrips, the larva carries a globule of brownish black excreta (on the first day the excreta are colourless), which, after attaining a considerable size and dropping on the leaf, dries to a blackish spot. These spots discolour the leaf, and their presence is a sure indication that the plant has been, or is being, attacked by the thrips. This globule of excreta is held off the surface of the leaf owing to the anal segments of the larva being slightly turned upwards.

The larvae when full grown drop from the leaf, and, crawling into a convenient crack in the soil, there change to prepupae. They prefer damp earth, and the prepupae are usually found at the junction of the damp and dry soil, which varies from about three to six inches down. Immature larvae falling to the ground will die if they cannot find food in the nature of weeds or crawl back to the plant, a very doubtful possibility. It may be noted that practically all weeds growing amongst the cotton support larvae. If the land is kept clean whilst the cotton crop is growing, this will not only prevent the larvae from maturing, but will make the adults seek other plants for oviposition. According to experiments, the adults do not live more than a day without food.

The larvae usually like to secrete themselves away from the sun, and are often found in large numbers in the curled up parts of the leaf. Larvae in the soil do not feed, and, if disturbed, move more quickly than on the leaf.

Habits of the Prepupa and Pupa.

The prepupae and pupae are found in the soil, though under unnatural conditions they have been observed on four occasions on the leaves. This peculiarity was not seen in the field. The larva, before prepupating, does not appear to make any cell, but crawls into any convenient place in the soil. The cast skins of the larvae and prepupae are found together, indicating that no movement of prepupae and pupae takes place. Both stages are capable of movement when disturbed, and are often seen in groups, and at other times singly or in pairs. The want of moisture in the soil does not have any deleterious effect, but from experiments and observations it would appear that if, after the larvae have crawled into the soil, the soil is kept moist and not allowed to crack, the adult is unable to emerge.

The prepupae and pupae possess red bands like those of the larvae; but whilst in the prepupae the antennae are carried forward in front of the head and the wing-lobes are partially formed, the antennae of the pupae are bent backwards over the head and the wing-lobes are well developed. The darkening of the body of the pupae previous to the emergence of the adults is very evident.

Food-Plants.

This thrips seems to feed on most plants, cultivated or wild, and below is a list of the plants on which the larvae have been observed. In course of time, no doubt, other plants will be found to sustain this insect, and attention may be called to the wide range of botanical orders represented in the list. Mr. R. E. Massey, Government Botanist, kindly identified most of the wild plants.

Cultivated Plants.

Potatoes, field beans, French beans, butter beans, ground-nuts, wheat, barley, peas, turnips, cabbages, cowpeas, bamia, beetroot, sweet potato, lettuce, carrot, clover and cotton, both American and Egyptian.

It has been reported as attacking Lubia (Lubia afin) and Dura, but this the writer has not been able to confirm.

American cotton suffers very much more than the Egyptian, and whilst Eygptian cotton recovers remarkably after a severe infestation, in the American variety the percentage of recovery is much smaller.

Wild Plants.

Malata, the most common plant in the Gezira, generally found with thrips.

Leucas nubica, Benth. (ungalot); very common, and always supporting thrips.

Phyllanthus niruri, Linn.

Tephrosia emeroides, Linn. (surep).

Cucumis melo, Linn.

Corchorus olitorius Linn. (molokhia).

Digera arvensis, Forsk. (heyrayrah).

Solanum incanum, L nn. (gibbein).

Ipomoea cordofana, Choisy (hantut or tubba).

Heliotropium europaeum, Linn.

Heliotropium supinum, Linn.

Ocimum basilicum, Linn. (rihan).

Polygala triflora, Linn.

Crotalaria sp.

Abutilon sp. (hambook).

Abutilon sp. (saphirah).

Rhyncosia memnonia, Linn. (myoda).

The local native names for most of the weeds are given in brackets.

Life-Cycle.

Observations were made on this insect only from the month of November to the beginning of August. It is doubtful if there is any aestivating period, and the writer is inclined to think that there is no resting stage though, after the rains commenced considerable search was needed to find specimens of the insect. The differences in the lengths of each stage are remarkable, but under absolute field conditions the life-cycle is a short one, and the thrips quickly reproduce in large numbers.

As the result of a number of observations and experiments it was found that the length of the egg stage varied from 4 to 15 days, with an average of 8·2. In February the minimum and maximum were, respectively, 9 and 15 days ; in March, 6 and 11 ; and in April, 4 and 9.

The period during which the larva remained on the plant varied from 3 to 6 days, with an average of 4·2. From 4 to 14 days elapsed between the entrance of larvae into the soil and the emergence of the adults, the greatest number of emergences taking place on the sixth day.

From this it will be seen that the developmental cycle may be as short as 11 days, or may take as long as 35 days ; but the writer is of opinion that 18 days may be regarded as the usual time, and the adults do not begin egg-laying until two days after their emergence from the soil.

Control Measures.

In discussing the control of this thrips, it should be borne in mind that its behaviour after the old cotton crop is removed till the new one is well advanced is not yet precisely known. Larvae were difficult to find on wild plants at the beginning of August, but until the rains commenced they were numerous.

Control may be considered under three heads, namely, suggestions, cultural methods, and insecticide applications.

1. *Suggestions.*

(*a*). If this insect spends the " dead season " on vegetation, all plants of every description should be removed ; but if, on the other hand, it rests in the soil, the ploughing of the old cotton land should take place as soon as convenient so as to expose the aestivating stage.

(*b*). Larvae and adults are very numerous on the last standing cotton, and the writer suggests that, since there is so little to be gained and so much to lose, the watering of the cotton should cease slightly earlier and the cotton should be cut out and burnt sooner ; by this means the number of thrips that could attack the succeeding cotton crop would be greatly diminished.

(*c*). Observations tend to show that heavy waterings have a detrimental effect on the numbers of thrips emerging from the soil. The probable reason for this is to be found in the fact that the soil does not crack so quickly, and the adults, unable to escape from the ground, succumb. The effect of irrigation on this thrips is a line on which further investigations are required. It is suggested that one or two heavy waterings about the beginning of November might have a very beneficial effect.

(*d*). Owing to the wide range of food-plants, experiments with trap crops should be tried.

2. *Cultural Methods.*

The cultivators of cotton in the Gezira appreciate the extent of the damage this insect can do, and the destruction of all weeds should be the first preventive measure to be adopted. Practically every plant in the vicinity of cotton has been found to harbour the larvae, and all vegetation growing amongst the cotton or in its vicinity should therefore be eradicated. This not only applies to the growing season, but is equally applicable to land which will be under cotton the following year, and to the banks of all canals and gadwels.

It should always be borne in mind that clean cultivation not only prevents, in many cases, the completion of the life-history of this insect, but also yields other advantages to the crops.

3. *Insecticide Applications.*

Four insecticides were experimented with, namely, pyridine sulphate, quinoline sulphate, nicotine sulphate, and soap.

Pyridine sulphate was found unsuccessful.

Quinoline sulphate possesses insecticidal properties, but the fact that it had to be used in strong solution, and therefore in large quantities, rendered it unsuitable.

Nicotine sulphate was tried with soap (" Sunlight ") in varying strengths, and the best solution found was one part of 32 per cent. nicotine sulphate to 1,200 parts of the soap solution, which was obtained by dissolving 1 lb. of the soap in 21 gallons of water.

Soap ("Sunlight") spray, consisting of one pound of soap to ten gallons of water, will kill a large percentage of thrips, both larvae and adults. Soap alone is only recommended if nicotine sulphate is unobtainable.

It should be stated that spraying is considered impracticable, as well as uneconomical, when the cotton is four or five months old ; but if the thrips should appear when the plant is small, the nicotine sulphate spray with soap will be found very useful. Spraying should be done in the late afternoon and evening, and at least twice, so as to kill the larvae which have hatched from eggs in the leaves since the first spraying.

SOME FURTHER NOTES ON THE TSETSE-FLIES OF NYASALAND.

By W. A. Lamborn, M.R.C.S., L.R.C.P.

Glossina morsitans.

A fortunate stay of a few days in July 1919 at Fort Johnston, Lake Nyasa, while waiting instructions, enabled the writer to proceed to the village of Mzeze near the Livingstonia Peninsula, where in 1914–15 some work was carried out on the various insects parasitic on the puparia of this fly.

The success at that time of the various parasites, especially *Mutilla glossinae*, Turner, as judged by the numbers of their cocoons found in old puparia of the fly and bred from recent ones, had been phenomenal, and so the chance, though one lasting only a few hours, of ascertaining the progress made by these insects in the course of the three subsequent years was a very welcome one.

The early rainy season was quite similar in character to that of 1915, when long series of the flies had readily been captured in the district, on passing through which one had been constantly harassed by a buzzing swarm. Far different was one's present experience, for though the journey was made on a cycle, which attracts more flies than a pedestrian, none at all appeared, and it was only on the following day that a single specimen was taken in the course of a hunt for puparia. Local natives agreed as to the diminution in numbers of the flies thereabouts without there being any falling off of game, and added that the pests had now become more numerous to the north, a statement substantiated by personal experience a few weeks later on.

A gang of six boys, who had on a previous occasion worked as puparia collectors and were therefore experts, were got together to assist again in collecting puparia, and the results were confirmatory ; for though two days were devoted to the search, only 107 old puparia and 15 new ones were forthcoming, mostly from the artificial breeding places designed in 1915. Examination of the old puparia showed that nine definitely had been destroyed by Mutillid parasites, but it was not possible to determine with certainty the full extent of the parasitism either by this species or others, owing to the age and broken condition of many of the puparia. Of the fifteen new puparia three only afforded flies, a male on 23rd August, a female on 1st September, and another female on the 4th. Five yielded *Mutilla glossinae*, two males on 17th September, one male on 18th, and one of each sex as long after as 29th. The remaining puparia all died, possibly as a result of the vicissitudes of temperature to which they were exposed, for they were taken on a month's foot journey in the uplands of Angoniland, at an average elevation of from 3,000 to 4,000 feet, hot days being generally succeeded by chilly nights.

Whereas in 1915 at Mzeze parasites would be readily obtained, at Domira Bay none at all were either captured or bred out, this being about fifty miles to the north and separated from the Mzeze area by the south-west arm of Lake Nyasa. No opportunity of visiting the area at Domira Bay occurred, but in September 1919 a visit was made to another section of it, at Kotakota, about forty miles north of Domira Bay, where between the 6th and 10th of the month hundreds of old *G. morsitans* puparia, and sixty-five new ones were obtained. None of these old pupa-cases showed the Mutillid cocoons, nor did any of these parasites emerge from

the new puparia, of which twenty-six yielded flies (twelve males and fourteen females) during late September and the first week of October, the remainder dying.

The *morsitans* area in the neighbourhood of the Livingstonia Peninsula and running inland for miles, so as probably to be continuous with the great area running down the west bank of the bed of the former Shire River, had undoubtedly been infested with these flies for many years, various natives, well on in years, stating that they remember them even when they were children ; whereas the area running from Domira Bay up north to Kotakota, and beyond it, and south towards Dedza, in which the fly is far more abundant, has undoubtedly been more recently occupied by them ; for many of the younger Government officials remember when large herds of cattle grazed on its wide dambos, now entirely destitute of all domestic animals, though there are large settlements of natives. The evidence would seem to suggest that the abundance of the fly thereabouts may be due to the failure of the natural parasites to keep equal pace with the fly in the migration which has occurred.

Glossina brevipalpis.

This species was found by the writer in the same area with *morsitans* in the course of a journey through a stretch of twenty miles of country between the mouth of the Bua River, twelve miles north of Kotakota, and that of the Duangwa, in every ravine and hollow where large shade trees were associated with heavy undergrowth. As showing how readily the presence of this fly may be overlooked it may be remarked that on the outward journey not one was seen, and that it was only on the return that the capture of two males in the early morning suggested a search. Many were then taken at dusk, and the numbers of the puparia obtained will show how numerous the flies really must have been.

On the 12th of the month a systematic search for their breeding places was commenced. A little scratching with a bit of stick in the loose sandy soil, much lightened by humus, among the herbaceous vegetation beneath a huge shade tree soon brought to light twenty pupa-cases ; more were found during the pitching of the tent, and a gang of raw natives who had been attentive to the mode of search were then put to the work. Within four hours the most industrious man had got together 390 puparia (old and new), two others bringing in 267 and 257 respectively, and between the 12th and 15th a total of no less than 13,838 old puparia, with 248 new ones, were found by them. At the same time in these breeding places only 23 puparia (17 old and 6 new) of *G. morsitans* were found, showing how different are the breeding places selected, for *morsitans* was present in swarms.

Twelve of the old puparia of *G. brevipalpis* were whole except for a small puncture which had probably given exit to parasites, though neither on this occasion, nor when the puparia were previously studied, were any of these obtained. The perforations were of two kinds, one about the size of the head of a small pin and situated usually midway between the two poles, and the other a much larger breach less regularly rounded and more commonly towards one or other pole. Twenty-eight only of the new puparia yielded flies (13 males and 15 females), and all the rest perished. All these flies came out an hour or two before dusk, except five, all males which emerged, four at about 10 a.m., one at 2 p.m.

On two successive nights camp was pitched in localities where these pupae were being obtained with a view to ascertaining whether *brevipalpis* is nocturnal as well as crepuscular in its habits. Though 32, all males, were taken at dusk, between 6 and 6.15 p.m., all within 50 yards of the tent, two only were taken inside it. None were taken after dusk, though the nights were bright and starlit, nor were they attracted to the camp lamps. At about 8 p.m. a search was made in the bush by the light of a bullseye lantern, but again the flies were neither seen nor heard ; and though the party of 23 natives slept out in the open, few having blankets, none complained of having been troubled by the fly.

The breeding grounds of this fly were further studied in October, some two hundred miles north in the vicinity of the Lufira River, North Nyasa, close to the Lake, a locality long notorious for the fly, the places selected by it having the same character as all the breeding places previously examined. In this neighbourhood 13 new puparia and 9,094 old ones were collected between the 7th and 18th of the month, only 14 of which showed perforations suggesting the exit of parasites.

In the course of the journey through the fly-infested villages north of Kotakota the method was witnessed by which the natives of that part, while sitting down, catch, with the least effort to themselves, flies settled within reach on their bodies. The blade of an old sheath-knife or an old spear blade is placed almost flat on the skin and is then advanced, with the edge slightly raised, by no means slowly or even very carefully, towards the fly, which, though very alert in regard to menace from above, evinces no apprehension of that below it. When the edge is well over its feet the native presses them on to his skin with it, and the fly, so trapped, is then taken in the fingers and subjected to treatment such as is doubtless considered justifiable by reason of the annoyance it has caused.

Suggestions in regard to Tsetse Control.

One of the most pressing entomological problems at the present day in the British Empire is that of the control of the various species of tsetse-flies. As shown by a number of workers, the parasites destructive to their puparia are not few, at all events in the case of *G. morsitans*, and in some areas these parasites are known to exert a considerable influence in reducing the numbers of the fly. But, generally speaking, no very material reduction, from the point of view of man, would seem to be effected by these agencies ; though at this early stage of research in regard to the fly it may perhaps be premature to make any unqualified statement as to their control value. Instances have been recorded where the tsetse-fly in a district has unaccountably diminished without there being any marked diminution in the numbers of the game animals therein. Major E. E. Austen in his " Handbook of the Tsetse-flies " (1911, p. 65) mentions the disappearance of *G. morsitans* from the Victoria Falls, where at one time it abounded. The late Captain F. C. Selous, in his book " African Nature Notes," speaks of the disappearance of the flies at the same time with buffalos from the valley of the central Limpopo and its tributaries, where other game—kudu, zebra, wildebeeste, hartebeeste, impala and bushbuck—continued to exist in considerable numbers, and he suggests that the flies died out because they were unable to maintain themselves on game other than buffaloes. More recent study of the flies has shown that this is not the case, and the writer

suggests that a more reasonable explanation is to be found in the local extermination of the flies by their parasites, a process, as he believes, now steadily proceeding in the area near Mzeze, Nyasaland. The question therefore naturally arises—how far is it possible to increase their influence either by the introduction of new parasites or by breeding on a larger scale those already known to science ?

The genus *Glossina* being now limited to the Ethiopian region, it is doubtful how far the parasites of other Diptera, brought in from other lands, would seek out and destroy its puparia. It is to be apprehended that those obtained from the puparia of other Muscids, breeding under more or less similar conditions, might do so. A more hopeful line of action could possibly be found in the search for other species naturally parasitic on *Glossina* but having a different geographical distribution. For instance a Bombyliid fly, *Villa lloydi*, Austen, parasitic on *G. morsitans*, has so far only been discovered in Rhodesia, and a second species of parasitic Mutillid, *M. benefactrix*, Turner, in Nyasaland only. The parasites of the fly on the West Coast are probably different from those in the East and South, the insect fauna, generally speaking, being largely distinct. The various species of tsetse-flies may each have different parasites yet to be discovered, which might be interchangeable.

It is probable, and some of the evidence on this point is very definite, that in the case of rapid extension of a fly area, parasites less endowed than their hosts with the power of ranging far and wide—strength on the wing having doubtless played a considerable part in the present-day success of the tsetse as an insect—have lagged more or less behind in the foci first inhabited by the flies. And this is particularly likely to be the case with Mutillids, the females of which are wingless. One of the present suggestions in connection with fly control is to endeavour to enhance the value of the parasites already known to science, the Chalcids in particular. They could unquestionably be bred readily enough in the laboratory on the puparia of their natural host, though owing to the difficulty in obtaining these in any numbers, the laboratory output would necessarily be very limited. It has occurred to the writer that it might be possible to employ as alternative hosts the puparia of some of the common Muscids, then liberating in great numbers the little insects, each with its dominant aim in life to seek out and destroy the greatest of the insect scourges of man and beast in the African Tropics.

The general upset of work as a consequence of war conditions made any attempt to put the idea to a practical test impossible, but an opportunity was made to carry out, during 1918 in East Africa and during the last six months of 1919 in Nyasaland, research work in regard to the question of alternative hosts for Chalcids normally parasitic on certain Muscids. The results (which will be written up later) showed some promise, though this work has again, unfortunately, been brought to a premature close.

THE EARLY STAGES OF WEST AFRICAN MOSQUITOS. V.—*CULEX DECENS*, THEO. AND *CULEX INVIDIOSUS*, THEO.

By J. W. S. Macfie and A. Ingram,
West African Medical Service.

Both *Culex decens* and *Culex invidiosus* are widely distributed in British West Africa. In the Gold Coast both have been taken in all the three divisions into which the country is divided, namely, the Colony proper, Ashanti and the Northern Territories ; the records at Accra showing the following distribution :—

Culex decens.

Colony—Accra, Cape Coast Castle.

Ashanti—Kintampo, Kumasi, Sunyani.

Northern Territories—Batiasan, Bawku, Binduri, Bole, Daweni, Dogan Kade, Jefisi, Kalleo, Kpalgu, Lorha, Mayoro, Nandaw, Nandawli, Nasia, Navarro, Pinna, Salaga, Sambolugu, Savelugu, Tamale, Tanina, Tiana, Tishi, Ulu, Wa, Yaga, Zuaragu.

Culex invidiosus.

Colony—Accra, Akuse, Bibianaha, Koforidua, Nsawam, Sekondi.

Ashanti—Akrokerri, Bjere, Kumasi, Obuasi, Odumase, Sunyani.

Northern Territories—Bawku, Bole, Gambaga, Kugri, Lorha, Maliki's Zongo, Navarro, Tumu, Turu, Wa, Zuaragu.

So far as they go these records do not point to any cleavage in the areas of distribution of the two mosquitos, both species having been collected in a number of the same places.

The majority of the records for the Northern Territories were made by one of us (A.I.) during a tour undertaken in 1918, the observations made at this time suggested that *C. decens* might be a domestic variety of *C. invidiosus*. Edwards (Bull. Ent. Res. iii, p. 381), however, considers the two to be distinct. In the adult, he says, " *C. decens* can be distinguished by the reddish thorax (that of *C. invidiosus* being brownish), and (in the male) the banded abdomen. In the female the abdominal banding is not constant ; the bands in *C. decens* are always narrow and may sometimes be interrupted." But he failed to detect any differences in the genitalia of the males (an observation which he repeated later, Bull. Ent. Res., v, p. 70), and was unable to separate the larvae, considerations which led him to admit that it was " quite possible that the two are really only forms of one species."

We have compared a number of larvae and pupae of these mosquitos in an endeavour to find some means of distinguishing them. We may say at once that we

were unable to detect in the larvae any constant difference of specific importance, and as this observation is in accord with that of Edwards further details will not be given.

In a previous paper (Bull. Ent. Res. viii, p. 85) we have described the pupa of *C. invidiosus*. The pupa of *C. decens* (= *C. nigrocostalis*, Theo., and *C. lividocostalis*, Graham) has been briefly described by Wesché (Bull. Ent. Res. i, pp. 40 and 45), but the details given are meagre. As it was necessary on this account to re-describe the pupa of *C. decens*, and as it seemed advisable to give at the same time further details regarding *C. invidiosus* because of the very close resemblance of the two pupae, we decided to compare seta by seta five specimens of each. The result of this examination will be recorded here in detail.

The pupae were found to be similar both in their general features and as regards the arrangement of their cephalo-thoracic and abdominal setae. In describing the setae the same method has been adopted as that employed by one of us in describing the pupa of *Stegomyia fasciata* (Bull. Ent. Res. x, pp. 161–172).

General Features.

In Table I the general features of the pupae are tabulated. The figures given are the averages of the measurements made in each case. The specimens of *C. invidiosus* examined were on the whole slightly smaller than those of *C. decens*. It will be observed that the general features of the two pupae were similar.

TABLE I.

General Features of the Pupae of C. decens *and* C. invidiosus.

	C. decens	*C. invidiosus.*
Length of pupa, extended ..	4–4½ mm.	4–4½ mm.
Respiratory trumpet, total length	640μ	580μ
length of the open portion (pinna)	170μ	160μ
ratio of the length of the closed portion (meatus) to the total length ..	1 : 1·4	1 : 1·4
Length of the tuft (A) at the posterior angle of the seventh abdominal segment	210μ	190μ
Length of the tuft (A) at the posterior angle of the eighth abdominal segment ..	210μ	190μ
Paddle, length	750μ	740μ
breadth	530μ	530μ
ratio of length to breadth	1·4 : 1	1·4 : 1

Cephalo-thoracic Setae.

The setae on the cephalo-thorax of these pupae are alike, and are similarly situated to those of *Stegomyia fasciata* (loc. cit.); they do not require special description. Details regarding the subdivisions of the cephalo-thoracic setae are furnished in the following comparative table (Table II).

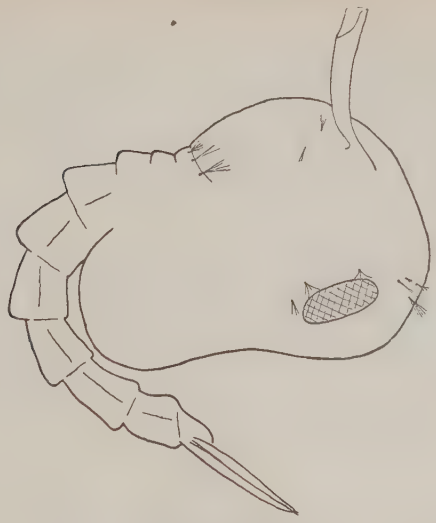


Fig. 1. Diagram showing the arrangement of the setae on the cephalothorax of the pupa of *Culex decens* or *C. invidiosus*.

TABLE II.

A Comparison of the Cephalo-thoracic Setae of the Pupae of C. decens *and* C. invidiosus.

Seta.	*C. decens.*	*C. invidiosus.*
Post-ocular,		
Superior; rather long, not especially strong ..	3	3–4, usually 3
Median; rather long, not especially strong ..	4–5, usually 4	4–5, usually 4
Inferior; rather long, not especially strong ..	3–4	3
Antero-thoracic,		
Lower anterior; moderate length, constituent hairs rather delicate	4–5	4–7
Upper anterior; rather small and delicate ..	1–5	3
Lower posterior; long, but not very strong	2	2–3, usually 2
Upper posterior; rather small and delicate, situated above the lower posterior seta ..	1–4	2–5
Dorsal; moderate length and strength	2–4, usually 4	3–5
Supra-alar; moderate length and strength	2	2–3, usually 2
Postero-thoracic,		
Internal; well-developed tuft of moderate length and strength	5–8	5–8
Median; rather long and strong	2–3, usually 2	2
External; tuft of moderate length and strength, or rather long	3–5	3–5

Dorsal Abdominal Setae.

The setae on the dorsal and lateral aspects of the abdomen may be described together. Details as to the subdivisions of these setae will be found in the tabular statement which follows; the facts given here are either of a general nature, or such as may be required to make the table comprehensible.

The following setae, which form series, are recognisable on each side of a typical segment of either pupa :—

1.—The *lateral seta* (A), situated a little above and internal to the posterior angle.

2.—The seta belonging to the *sub-median row* (C), on the dorsum, situated near the posterior margin of the segment about half way between the posterior angle and the middle line of the abdomen. This is the row of setae which on a previous occasion (Bull. Ent. Res., x, p. 59) was referred to as the *inner lateral row*.

3.—A very small seta (C′), situated near the posterior margin of the segment and a little internal to C.

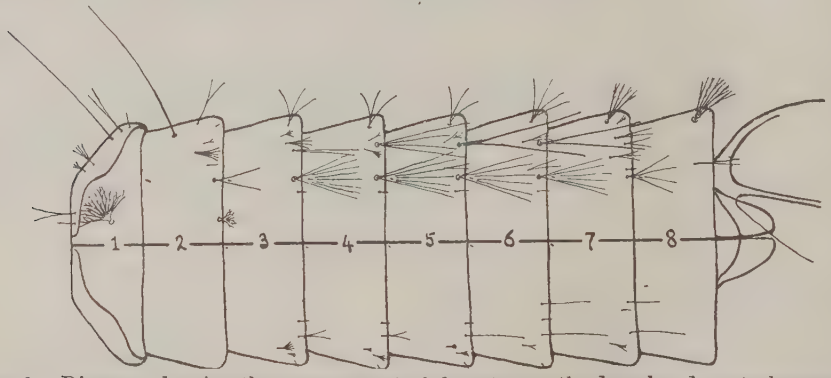


Fig. 2. Diagram showing the arrangement of the setae on the dorsal and ventral aspects of the pupa of *Culex decens* or *C. invidiosus*; dorsal setae shown on the upper, ventral setae on the lower half.

4.—The seta belonging to the *sub-lateral row* (B) on the dorsum, situated near the posterior margin of the segment about half way between the posterior angle and C. This is the row of setae which on a previous occasion (Bull. Ent. Res., x, p. 59) was referred to as the *outer lateral row*.

5.—Two setae (B′ and B″) situated a little anterior to the posterior margin of the segment; B′ outermost and always more or less external to B, B″ internal to B′ and on some segments external, on others internal to B. B″ is sometimes associated more closely with C than with B, for example on the sixth segment.

6.—A very minute seta, the *anterior dorso-central seta* (D), near the anterior margin of the segment in line with the setae of the sub-median row.

These seven setae are easily recognised on the third to the sixth segments; the setae on the other segments do not conform completely to this plan and require a few words of explanation.

Segment I. The setae on this segment are arranged in a similar manner to the corresponding setae of *Stegomyia fasciata*, and the same names are used in describing them, namely, Dendritic tuft for the large branched seta in the middle of the segment near the median line, and, for the setae along the proximal border, from within outwards, Antero-internal, Antero-external, Medio-internal, Medio-external, Postero-internal, Postero-external and Lateral.

Segment II. Nine setae may be seen on this segment in a dorsal view, of which C and D are as defined above. Internal to C, near the posterior margin of the segment, is a small dendritic tuft (D. T.). The setae external to C are as follows: a small single seta (B) a little external and anterior to C, a tuft of moderate size (B″) a little external and anterior to B, and a small tuft (B′) a little external and posterior to B″. Laterally, or ventro-laterally, there are three setae: the most anterior (A′) a very long, stout seta; rather posterior to A′ a seta (A) similar to the Lateral setae on the more posterior segments; and posterior to A a very small seta (S) similar in appearance to the Postero-lateral setae on the ventral aspect of the abdomen.

Segment VII. A, B, B′, B″, C, and D as defined above. There is no small seta internal to C, but a little external to it there is a small seta similar to C′ on the other segments; this seta is referred to in the Table as C′. In addition there is a small tuft (A′) close to and a little posterior to A.

Segment VIII. A and D as defined above. In addition there is a delicate seta (P) situated close to the external margin of the root of the paddle. At the distal end of the midrib of the paddle there are two very small setae (P′ and P″); usually single, but sometimes forked at their ends or even divided more deeply.

TABLE III.

A Comparison of the Dorsal Abdominal Setae of the Pupae of C. decens *and* C. invidiosus.

Segment.	Seta.	*C. decens.*	*C. invidiosus.*
I.	Dendritic tuft; large and well-developed, strong primary branches	8–12	8–11
	Antero-internal; short, rather stout	1, end occasionally forked.	1
	Antero-external; rather long and strong	2–3, usually 2	2
	Medio-internal; small	1, or a small tuft*	1, or a small tuft
	Medio-external; small, but longer than the Medio-internal	Tuft of about 2–5 hairs.	Similar tuft
	Postero-internal; very long, strong	1–2, usually 1	1
	Postero-external; rather long and slender	2	1–3
	Lateral; small, delicate	1, end sometimes divided.	1, end sometimes divided.
II.	A; rather long and slender	2	1–3
	A′; very long, strong	1–2	1–2
	S; very small and feebly chitinised	1	1
	B; small, rather stout	1	1
	B′; small tuft	Small tuft of 2–5 hairs	Similar small tuft
	B″; small tuft, but considerably larger than B′, situated between B and B′ and anterior to them	Tuft of 4–6 hairs	Tuft of 4–6 hairs
	C; moderate length, reaching nearly half way across the third segment	2–3, usually 2	2
	D.T.; small dendritic tuft	Small dendritic tuft	Small dendritic tuft
	D; minute	1	1
III.	A; rather long and slender	2–3	2–4
	B; rather long and strong	2	2
	B′; small tuft between A and B″	Small tuft, 1–7 hairs	Small tuft, 1–4 hairs
	B″; tuft, considerably longer than B′, situated between B and B′	Tuft, 3–7 hairs	Similar tuft

*In the case of small tufts, the number of constituent hairs, when given, is only approximate as it was often impossible to determine with accuracy the degree of sub-division.

Segment.	Seta.	*C. decens.*	*C. invidiosus.*
	C ; well-developed tuft, reaching about half-way across the fourth segment	6–9	6–12
	C′ ; small	1	1
	D ; minute	1	1
IV.	A ; rather long and slender ..	2–4	3–4
	B ; long, strong, reaching almost across the fifth segment ..	3–4	4–6
	B′ ; small tuft, external to B ..	Small tuft, 1–3 hairs	Small tuft, 1–3 hairs
	B″ ; small tuft, anterior to B ..	Small tuft, 4–6 hairs	Small tuft, 4–7 hairs
	C ; well-developed tuft reaching further than half-way across the fifth segment	4–8	6–10
	C′ ; small	1	1
	D ; minute	1	1
V.	A ; rather long and slender	3–4	3–4
	B ; very long and strong, reaching beyond the posterior margin of the sixth segment	2	2
	B′ ; rather small tuft, external to B..	Small tuft, 2–5 hairs	Small tuft, 2–6 hairs
	B″ ; moderate length, external and anterior to C	1–2, usually 2	2–3, usually 2
	C ; well-developed tuft, reaching further than half-way across the sixth segment	4–8	6–7
	C′ ; small	1	1
	D ; minute	1	1
VI.	A ; rather long and slender.. ..	3–4	3–5
	B ; very long and strong, reaching beyond the posterior margin of the seventh segment	2	2
	B′ ; small tuft, external to B ..	2–4	2–4
	B″ ; moderate length, situated external and anterior to C	2	2
	C ; well-developed tuft, reaching about half-way across the seventh segment	4–7	4–8
	C′ ; small	1	1
	D ; minute	1	1
VII.	A ; constituent hairs strong, usually sub-plumose and often branched, sometimes simple	3–5	2–4
	A′ ; small tuft	Small tuft	Small tuft
	B ; moderate length and strength ..	2	1–3
	B′ ; moderate length, external to B..	2	2
	B″ ; moderate length, internal to B..	1–4	2–5
	C ; moderate length, reaching about half-way across the eighth segment	2–5	4–7
	C′ ; small, external to C	1	1
	D ; minute	1	1
VIII.	A ; well-developed tuft, constituent hairs strong, usually branched and sub-plumose	6–7	5–9
	D ; minute	1	1
	P ; moderate length, slender ..	2	2
	P′ and P″ ; very small	Two small setae	Two small setae

Ventral Abdominal Setae.

The setae present on each segment, as well as the characters of the setae, are shown in the following tabular statement (Table IV).

TABLE IV.

A Comparison of the Ventral Abdominal Setae of the Pupae of C. decens *and* C. invidiosus.

Segment.	Seta.	*C. decens.*	*C. invidiosus.*
III.	D ; very small, feebly chitinised ..	1	1
	E ; small tuft, longer than E′ ..	Small tuft, 4–5 hairs	Small tuft, 2–5 hairs
	E′ ; small tuft	Small tuft, 2–5 hairs	Small tuft, 4–5 hairs
	C ; moderate length	2	2
	B′ ; small	1	1
	A ; minute	1	1
IV.	D ; very small, feebly chitinised ..	1	1
	E ; small tuft..	1, or small tuft, 2–5 hairs.	Small tuft, 2–4 hairs
	E′ ; small tuft, longer than E ..	1, or small tuft, 2–6 hairs.	1, or small tuft, 2–4 hairs.
	C ; moderate length	2	2
	B′ ; small	1	1
	A ; minute	1	1
V.	D ; very small, feebly chitinised ..	1	1
	E ; small tuft	1, or small tuft, 2–4 hairs.	Small tuft, 2–4 hairs
	E′ ; small tuft, longer than E ..	Small tuft, 2–5 hairs	Small tuft, 4–7 hairs
	C ; rather long, reaching fully half way across the sixth segment ..	1	1
	B′ ; small	1	1, end sometimes forked.
	A ; minute	1	1
VI.	D ; very small, feebly chitinised ..	1	1
	E ; small	1, or small tuft, 2–4 hairs.	1, or small tuft, 2–3 hairs.
	C ; rather long, reaching fully half way across the seventh segment	1	1
	B ; rather long, shorter than C ..	1	1
	B′ ; small	1–2, usually 1	1–2, usually 1
	A ; minute	1	1
VII.	E ; small tuft	Small tuft, 2–4 hairs	Small tuft, 2–4 hairs
	C ; rather long, reaching fully half way across the eighth segment.	1	1
	B ; moderate length	1	1
	B′ ; small, end sometimes forked or sub-divided, a little external and anterior to B	1–2	1–4, usually 1
	A ; minute	1	1
VIII.	A′ ; minute	1	1

The setae on the ventral aspect of the abdomen are few, and mostly inconspicuous. The following setae, which form series, may be recognised on each side of the abdomen of either pupa on two or more of the segments :—

1.—A small seta, the *medio-lateral seta* (E), a little internal to the lateral border and rather posterior (junction of the posterior and middle thirds) to the middle of the segment.

2.—A very small seta, the *postero-lateral seta* (D), in a lateral position just above the posterior angle.

3.—A small seta (E′) a little posterior and external to E.

4.—The seta belonging to the *inner ventral row* (B).

5.—The seta belonging to the *outer ventral row* (C).

6.—A small seta (B′) near the posterior margin of the segment a little internal to C.

7.—A very minute seta, the *anterior ventro-central seta* (A), at the anterior margin of the segment and very close to the middle line of the abdomen.

Two setae require special mention. On the eighth segment there is a minute seta (A′) near the anterior margin of the segment a little internal to the level of B on the seventh segment. This seta resembles A, but is placed more externally and posteriorly than A on the more anterior segments. On the seventh segment the small seta internal to C is situated close by and a little anterior to B ; we have therefore marked it B′, and have retained this symbol for the similar setae on the more anterior segments which, however, are situated nearer the posterior margin and more externally.

It is clear from the descriptions which have just been given that the setae of the pupae of *C. decens* and *C. invidiosus* are similar in character and situation, and that although they are somewhat variable as regards their sub-divisions the degrees of variation of the two overlap. In fact, they provide no feature of differential importance.

The question then arises, are *C. decens* and *C. invidiosus* separate species or are they varieties of a single mosquito. There are indeed certain differences in the adults, but the genitalia of the males are identical according to Edwards, the larvae cannot be separated, and the same remark applies to the pupae. Under these circumstances we think there can be little doubt that they should be regarded as varieties and not as distinct species ; we propose to retain for the species the name *C. decens*.

SOME NOTES AND REMARKS ON THE BIONOMICS OF *GLOSSINA MORSITANS*.

By Rupert W. Jack, F.E.S.,

Agricultural Entomologist, S. Rhodesia.

It is with considerable diffidence that the writer has prepared the following paper, not only on account of several previous contributions to the subject, but also, and chiefly, because no opportunity has been available for more than comparatively brief visits to the fly areas in Southern Rhodesia, and the observations to be recorded are therefore of a somewhat meagre nature compared with work that has been carried out of recent years in other parts of Africa. The tsetse-fly problem is, however, of such paramount importance to Africa as a whole, and the continued extension of the fly belts such a grave hindrance to the full development of Southern Rhodesia, that it is felt that too much time and thought cannot be devoted to the subject, and that every contribution whether of actual observations or of theoretical deductions, or of both, must have a certain value, if only in provoking discussion and criticism. In the following pages the important question of whether or not *Glossina morsitans* is vitally dependent upon the larger mammals is not directly dealt with. The strong trend of scientific opinion in the direction of an affirmative conclusion must be admitted at the present day by the most vigorous opponent of the theory. There is hardly an investigator of any standing who has not contributed some observations of weight, indicating that the fly is mainly dependent upon the larger mammals for its food supply. For the purposes of the present discussion this dependence has been to a large extent assumed with a view to an attempt to explain certain phenomena upon this basis. The discussion is, however, of a very disconnected nature and aims merely at touching upon a few points in connection with the bionomics of the fly that need clearing up, and if the writer's views provoke criticism, or even direct contradiction, supported by actual observations, the paper will have served its purpose, as our knowledge of the subject cannot fail to benefit thereby.

It will be found that there is a very substantial agreement between observations in this territory and those recorded further north, particularly in Northern Rhodesia, but there are several important points bearing on the fly problem concerning which a considerable difference of opinion appears to exist, and others that have not apparently been touched upon as yet.

The points raised include :—(1) the conditions in the dry season in respect to the welfare of the fly ; (2) the effect of grass burning on the numbers of the fly ; (3) the value of mopani country to the fly ; (4) the question of migration under the influence of hunger or other stimulus ; (5) the question of fly moving about infested areas with game ; (6) the distance at which the fly can detect its hosts ; (7) the following distance of female flies.

In the following pages it is desired to emphasise the importance of these points, stating the writer's own attitude of mind towards them in the light of available evidence, but without preferring any claim to having reached a final conclusion. Direct investigation of several of the points is planned for early attention if circumstances permit, and it is hoped that other investigators will carry out similar researches so that definite solutions may be reached.

Conditions in the dry Season.

Dr. H. Lyndhurst Duke, of Uganda, in a recent paper* refers to the dry season as a time of stress and reduced breeding rate for the fly in that territory. Lloyd's records concerning Northern Rhodesia are quoted as parallel observations, although the latter's statement to that effect applied only to the earlier part of his work in the Luangwa Valley (Bull. Ent. Res. iii, p. 234) and his later work on the plateau led to exactly the opposite conclusion, namely that breeding was practically confined to the warmer part of the dry season (Bull. Ent. Res. v, p. 58). Lamborn in Nyasaland has made several statements on this point. For instance, in his Third Report on *Glossina* Investigations in Nyasaland (Bull. Ent. Res. vii, pp. 29–50) on page 30 we have the statement : " The small number of living pupae is to be accounted for by *the breeding being at its minimum during the late dry season* " (July). On page 36 he states : " Now as the dry season draws to a close pupae are being produced more freely;" and on page 46, " The breeding season for *G. morsitans* is in full swing, just as the rains are about due." It would seem that the period when the dry season " draws to a close " and " the rains are about due " might without inaccuracy be described as " the late dry season " in preference to July. Nevertheless Lamborn's contention is quite clear, namely that the breeding season is at its minimum in July, and is in full swing in October, when the first rains may be anticipated both in Northern and Southern Rhodesia. In Southern Rhodesia, however, the October rains are normally very local and may not occur at all, and dry season conditions frequently prevail well into November. October and November (before heavy rains set in) are well known as the hottest months of the year and the term " latter part of the dry season " would appear naturally to include the period from the beginning of August to the opening of the heavy " planting " rains, which usually commence about mid-November. In some seasons they are, however, postponed until well into December, and in such circumstances, as the veld still maintains a dry season character, observations on breeding rates, etc., are still influenced by late dry season conditions, and this should be made clear.

Observations on the seasonal breeding rate in Southern Rhodesia are insignificant compared with those in Northern Rhodesia and Nyasaland, owing to the fact that no officer has been available to devote even the bulk of his time to the tsetse-fly problem. There is not the least doubt, however, that the fly may, under favourable conditions, breed very freely during the latter and warmer part of the dry season (August to November). Observations at Sipane Vlei, already published, leave no doubt upon that point. It would seem therefore that conditions in Nyasaland, and Northern and Southern Rhodesia are similar in this respect, at least as regards the plateaux. In Uganda on the other hand the published records of rainfall in the Masindi area and at Mpumu show that the climate is very different, the dry season being much less clearly marked and of much shorter duration.

In 1911 the writer called attention to a marked difference in the distribution of fly in the dry and wet seasons.† The dry season haunts of the fly in Southern Rhodesia have been described more than once. They consist of centres where shady evergreen

*Bull. Ent. Res. x, p. 20, lines 11–13, and elsewhere.

†Bull. Ent. Res. ii, pp. 357–361.

trees exist and apparently correspond more or less to the areas termed "foci," "primary centres," etc., described later in Central and East Africa. These dry season haunts undoubtedly vary to a considerable extent in their efficacy as favourable habitats for the fly, as is indicated by the fact that some of them are intensely and others little infested. The type of dry season haunt where the fly is generally met with in the greatest numbers consists of a vlei, with the necessary evergreen trees along at least some portion of its margin, in a part of the fly area where vleis are scarce. Surface water may be present, or not, but the underground supply is always much nearer the surface than in the surrounding country, with the result that green grass starts growing with the warm weather long before the rains commence. The green grass in the vlei, especially after the dry grass has been burnt off and the young grass has begun to grow, is intensely attractive to grass-feeding animals, which often concentrate in considerable numbers around an isolated spot of this nature and move in regularly during the afternoon to feed, passing perforce through the haunts of the fly in doing so. In this way the flies obtain more or less regular meals and the whole conditions appear to be ideal for rapid increase during the latter part of the dry season, namely, regular food, warm weather and shelter for the larvae and pupae. Such centres might conveniently be termed "first grade foci."

In other parts of the fly areas rivers and vleis are much more prevalent, and intense concentration of both game and fly does not occur. The dry season haunts of the fly correspond, however, with the best grazing grounds at this time of the year, on account of the fact that the superior underground water supply supports both evergreen trees that shelter the fly and green grass that attracts the game. The term "second grade foci" might be permitted in this connection.

In other places again, the fly affects shady forest bordering rivers, streams or dry water-courses, and although not the main grounds, game has a tendency either to lie up in such situations during the day, or to pass through for the purpose of drinking. In the writer's experience, wart-hog, water-buck, kudu, impala and small buck are very commonly found in this type of forest during the daytime, whereas certain types constitute the permanent home of bushbuck. Such spots are rarely heavily infested and may be termed "third grade foci."

It must be borne in mind that animals of all sorts seek the shade during the heat of the day in hot weather, and as the fly is also dependent upon shade, fly and game must in general tend to meet at the time of year when shade is restricted more readily than at other times when shade, water and grass are everywhere to be found. Provided, therefore, that the temperature is suitable for breeding to proceed at the maximum rate, the dry season should in a general way be more favourable to the fly, assuming its dependence on the larger mammals for its food supply, than the wet.

It does not follow, however, that this is necessarily the case in particular instances. Certain tracts of country dry up so thoroughly towards the end of the dry season that they are deserted altogether by most species of game. As has been remarked by several observers, however, wart-hog and duyker are usually to be found even after the grass has been burnt off over a wide area. These species, especially wart-hog, may serve to keep the flies from starving, but conditions cannot be said to be favourable to increase. Fly under such conditions is almost invariably very hungry, the proportion of the sexes caught tends to approach equality and pupae are

extremely scarce.* Fly appears to be extremely numerous and is certainly extremely pertinacious. Half-a-dozen flies that are eager for blood give a far greater impression of numbers than half-a-dozen "following" males. Fifty or sixty really hungry flies would give the impression of hundreds. Several investigators have indeed drawn attention to the fact that the numbers of tsetse under such conditions may be more apparent than real. The writer can only speak with experience of one locality of this nature (Gorai River, Lomagundi), but a noteworthy point was the extreme localisation of the fly, few being met with except at the point where the path crossed the water-course, and here they seemed to swarm. When the writer camped at this spot for several days, the flies became very much less troublesome. Many presumably fed on the two dogs accompanying the party, and a few on the natives. Some 80 odd were caught, and the party was then left in comparative peace. Nowhere else in the dried-up triangle of country formed by the Hunyani and Ambi Rivers with the escarpment were flies met with in any numbers.

The following April no fly was encountered at the river crossing, but they were present in the neighbouring mopani forest in very moderate numbers, giving the impression of a decrease since the previous November. In regions such as this it is judged that the wet season must constitute the main breeding period, owing to the return of game with the rains, but that under these conditions the fly does not attain the same numbers as in areas where more favourable winter haunts are found. The visitor in the dry season meets, however, a large proportion of the fly population at once, whereas if game is plentiful he probably meets only a fraction.

This argument may not apply universally to localities where fly seems numerous and game very scarce. In the area referred to it was actually shown that game was moderately plentiful when the country was not dried up. Data for times of year other than the dry season appear to be lacking in respect to most of the classic instances where fly apparently abounded in the absence or extreme scarcity of game.

During the earlier part of the dry season, in May, June and July, the coldest weather occurs, and there is little doubt that the fly breeds less freely at this time of year and that the pupal period is more prolonged, both of which facts tend to check increase. On the whole, the fly tends to be less numerous at this time of year, particularly in July, but during August and onwards to the advent of the rains considerable increase occurs. With the advent of heavy and persistent rains the fly scatters and therefore appears to decrease suddenly, although this is probably only apparent.

The answer to the question as to whether the dry season is in general a period of stress for the fly or not, except in so far as the breeding is influenced by temperature, would appear therefore to be in the negative as far as conditions similar to those of this territory are concerned, and the writer is of opinion that, excepting certain localities, far from being a time of stress, the latter part of the dry season is probably the most favourable and important period of the year under normal conditions. Furthermore, it would appear that the later the rains are in commencing, the greater the insects' capacity for increase. That such conditions are not inimical to the fly

*The writer is largely repeating results obtained by others in Central and East Africa, although observations in S. Rhodesia are entirely in accord.

is shown by the fact that the latest onset of the rains recorded in recent years in the territory, namely in 1912, when no appreciable rain fell till towards the middle of December, was followed next year by the largest extension of fly recorded in connection with the Sebungwe fly area.

The Effect of Grass Fires.

Another point is the stress laid by certain investigators on the efficacy of grass fires in reducing the fly. The present writer has been unable to obtain the slightest evidence that grass fires in this territory have any material effect on the number of fly, indeed the evidence to the contrary is almost conclusive. One of the most striking instances was recorded on the Gaori River below the escarpment in the Lomagundi district. Fly in November 1910 was still confined to a dry season haunt, which consisted in this case of shady trees on the bank of the dry water-course mentioned above. For some reason the grass had not been burnt until three days (according to the natives) before the writer's visit, and the presence of still smouldering trees and the general appearance of the ashes of the grass showed it to have been burnt extremely recently. The fire had swept through the country over a very wide area. Fly was present in considerable numbers, as already mentioned, attacking the party very persistently. When a second visit was made to the spot in April of the next year, it was found that the grass throughout the " focus " stood as high as a man's chin and was so thick that it was far too laborious to attempt to make headway through it. The fire the previous November must therefore have thrown up flames twelve to fifteen feet into the air. These fires are an annual occurrence, here as elsewhere, and yet this little water-course is well known to all using the path which crosses it, as a fly centre, where the pest is always very much in evidence in the dry season. This was, as a matter of fact, the reason why that particular foot-path was followed. Many other less striking instances have come to the writer's notice during the past ten years, and the accumulated evidence has induced an entire loss of faith in the efficacy of grass fires in reducing the fly. As a matter of fact if tsetse-flies could not avoid grass fires they would surely long ago have been exterminated in parts of the country inhabited by natives. Of course even in Southern Rhodesia much patchy burning of the grass occurs, but the long, intensely dry winter presumably favours burning over wide areas more than conditions in Uganda, for instance. It is difficult to see how the flies could avoid a roaring furnace like that along the Gorai River by mounting in the air unless they went to a very great height (for a fly), but the contiguous mopani would afford a refuge, as in this type of forest the grass is always very short, and is sometimes almost altogether wanting. If large areas of country infested with fly were covered with long thick grass better results might be anticipated. Possibly this is the reason that greater effect on the fly has been noticed elsewhere.

The Value of Mopani Country to the Fly.

Both Duke and Fiske, referring to Uganda, speak of the fly showing hunger in the long grass season, which is of course the latter part of the wet season and earlier part of the dry. This is attributed to difficulty in locating game. The point is extremely interesting, because from Duke's description of the Masindi area comparatively long

grass apparently occurs over wide areas. Conditions differ in various parts of the fly-infested areas of Southern Rhodesia, but in the great majority mopani belts are a feature of the country, and the fly certainly shows a strong preference for this type of forest in the wet season, deserting its dry season haunts where the grass is usually long and thick, sometimes very long. The sweet short grass of the mopani is very attractive to many species of game in the wet season, though the reverse in the dry, and the fly certainly has the best chance of meeting and perceiving game in this type of country during the rains. The mopani grass, however, dries up very quickly after the cessation of rains, being shallow-rooted and of little substance, so that it loses its special attractiveness very shortly after the close of the wet season. Nevertheless, this type of forest is much haunted by impala and wart-hog even at that time, and many other species are commonly seen in it, if game is at all plentiful in the neighbourhood. Whilst, therefore, it is probable that in Southern Rhodesia the long-grass season is not in general a time of stress for the fly, the fact is in no way opposed to Fiske's observations. In this connection it may be mentioned that the only sex count made by the writer in the long-grass season was in April 1911, with fly taken in mopani, and resulted in 53 males to 3 females, by far the most extreme disparity yet recorded in the territory. The fly's habit of avoiding thick undergrowth would indeed suggest a difficulty in finding its hosts in such an environment. It is quite possible that in certain parts of the fly areas in Rhodesia a time of stress for the fly may occur in the long-grass season, as the mopani is not ubiquitous, being absent, so far as the writer is aware, from most of the Jetjenini fly area and from certain parts of the Sebungwe area. Prospectors and hunters in this territory have constantly associated mopani and tsetse, and although obviously not essential to the tsetse, it is quite possibly of value to the fly under certain conditions. According to Fiske's observations it ought theoretically to be of value in the long-grass season, and possibly it affords a refuge from grass fires.

The Question of Migration.

The next point is the question of the migration of fly, corresponding to the movements of game, or under stress of hunger. Now it is far from the writer's intention to adopt a dogmatic attitude on this subject, but it would seem difficult to reconcile any habit of this nature with a number of known facts. First, in regard to the question of fly migrating with game, we have the phenomenon of restricted fly-areas and their mode of extension. It has already been pointed out (Bull. Ent. Res. x, p. 88) that the limits of a fly area are not necessarily permanent. The permanent limits are marked by the impingement of favourable on unfavourable country; that is to say, the country beyond the limit is for some reason or other unsuited to the tsetse. Transitory limits are, however, formed by the high-water-mark, so to speak, of the advancing flood when the fly is spreading, as has been the case in this territory since the rinderpest. Transitory limits would also be apparent if the pest were receding.

The advance of the pest is, however, comparatively slow, and in no way comparable with the powers of movement of the fly itself or of game. Much potential fly area, known to have been infested in pre-rinderpest days, is still free from the pest, although the latter is gradually occupying more and more of its old country.

Is it possible for these conditions to obtain if the fly had a habit of migrating with herds of game, apart, of course, from the males' habit of temporarily accompanying moving animals and human beings ? Herds of certain species of game are more or less constantly on the move in and out of the fly area, and if the fly accompanied them in their wanderings the whole of the potential fly area would certainly be very quickly occupied.

It may be contended, however, that the fly only follows " trekking " game under stress of hunger. This appears to imply a rather marvellous instinct on the part of the fly. Any fly suffering from hunger that encounters a herd of game is likely to be a full-fed fly in a space of time measured by minutes, and is then not in a condition to follow anything for some time. Must we, therefore, suppose that the fly restrains its appetite in order to accompany the herd into another part of the country ? Again, game travels as a rule by night, and though there are numerous records of fly " biting " on warm nights, it is essentially of diurnal habit. Finally, we have apparently no records to show that the female flies follow animals or human beings for any appreciable distance at all, whether they are hungry or not. The writer's observations are all to the contrary, and published accounts apparently give no record of other than males exhibiting an obvious following habit. Much argument has in fact been based upon the supposition that the female flies only seek animals and human beings for the purpose of feeding, whilst the males follow for other reasons.

These considerations have led the writer to be extremely sceptical concerning the fly's alleged habit of migrating with game. Regular movements of game in a given direction might, it is admitted, help the spread of the fly in that direction. The allusion is to the daily movement of game from its feeding grounds to water, as, for instance, game which feeds in the neighbourhood of a dry river and moves across to a flowing one to drink (e.g., the Mzola and Kana Rivers in this territory). In the same way, regular traffic along a road would tend to spread the fly, if conditions admit of spread, but this is quite apart from the question of fly migrating with migrating game.

The second aspect of the question is that of fly migrating without help from moving game, when pressed by hunger. This would be a serious state of affairs ; as they might be attracted by the settler's herds of cattle, take up their residence in the vicinity of his " kraal " and deposit their larvae under his orange trees. Such a development might well have happened in the writer's experience if hungry fly had a habit of migrating even three or four miles to a food supply. The important point is that it did not happen. The idea of this form of migration has, as a matter of fact, always puzzled the writer. How is it supposed to take place ? Do the tsetse send out scouts like bees to locate a better piece of country and then rise in a swarm to follow these guides to the new locality ? Does some instinct inform them that better conditions prevail elsewhere, so that they rise with a common impulse and migrate thither ? Do they, under stress of hunger, migrate *en masse* at random guided by chance, or perhaps the direction of the wind ? Do they migrate by a series of short journeys, gradually tending day after day in one direction ? Unless the movement takes place at random, this presupposes a knowledge of where

better feeding grounds are to be found. Or, finally, do they migrate individually ? In the latter case they might take many directions and a corresponding increase in another part would not be likely to accompany the decrease in the original centre. Fortunately for the neighbouring settlers, where we have had a clear case of hunger conditions as regards game, in the Hartley district, the diminishing fly became gradually restricted in range as the game decreased, and still adhered to their old haunts, whilst numerous cattle worked with more or less impunity amongst the Shagari mines a few miles away on the one side, and settlement proceeded along the railway line with rapidly decreasing losses on the other. The destruction of the usual haunts by the felling of the forest did, however, appear to cause a scattering of the tsetse, which died out, probably in consequence. The fly along the Gorai River, mentioned above, were obviously very hungry at the time of the writer's visit in November 1910 (out of some 82 flies caught actually more were females than males), and from all accounts this is an annual occurrence at this spot ; but although game was more abundant on the Hunyani a few miles away, the flies apparently preferred to endure hunger in this area rather than migrate. They were not, it must be confessed, absolutely starving, as wart-hog and duiker were actually seen in the fly haunts ; but their meals were without doubt sufficiently irregular to keep the appetite of the majority very keen. Fly, on the other hand, was comparatively scarce on the Hunyani where more game was to be found.

The writer has, in fact, been able to find no evidence during the past ten years in this territory that the fly has any tendency to migrate, apart from the seasonal scattering during the wet season, as a result of which the pest is much more uniformly distributed over the infested area than during the dry season. Although new areas have been invaded by its gradual spread, no incursion of fly into localities other than those immediately adjacent to the former infested areas have occurred. It is readily admitted that an *apparent* migration might take place in the course of time, the fly increasing in a newly invaded area and decreasing in the old, but this does not imply migration. In any case in Southern Rhodesia the invasion of new areas, in the writer's experience, has not been accompanied by any corresponding reduction elsewhere, nor has reduction in an old area been accompanied by any noticeable increase elsewhere. The fly appears to increase or decrease in any area solely in relation to its ability to breed successfully.

On the whole there seems little reason at present to believe in any form of migration in respect to *Glossina morsitans*, other than the seasonal scattering with the advent of the wet season, and forced movements induced by destruction of the forest. In the latter case the fly naturally follows the receding shade.

The Question of Fly moving about Infested Areas with Game.

The idea that fly locates game and follows its movements more or less continuously, at least within the limits of infested country, is not absent from the writings of serious investigators. In this connection it is essential to distinguish between following for a limited distance, as is the well-known habit of the males, and possibly of the females to a much less degree, and the alleged habit of the fly attaching itself to the herds and accompanying them in their wanderings day after day. The writer has been able to find no direct evidence adduced in support of this idea,

and there are certainly many reasons why such a habit is, to say the least of it, unlikely. The question is intimately connected with that of fly migrating with game; for if the fly followed herds of game within the infested area, there appears to be no obstacle to its following the herds beyond it, provided that the country entered is potential fly country. This, as an attempt has been made to show, is at least not its general habit. The further difficulties in the way of accepting this idea, mostly already mentioned, may be briefly summed up as follows:— (1) female flies are apparently not known to follow to any great distance at any time; (2) gravid females seek seclusion, and are not in the least likely to attempt to follow a moving herd; (3) hungry flies tend to feed fully, and full-fed flies abandon their hosts, which are unlikely to remain in the vicinity until the flies recover; (4) the fly is diurnal in habit, whilst game moves largely at night. It would seem therefore that the only individuals capable of following game even for a few hours are those which do not desire to feed. The majority of observations indicate that only the males exhibit a tendency to follow, although the possibility of non-gravid females doing so is not altogether excluded. In any case it is well known that even the males do not follow human beings for more than an hour or so, but gradually fall away, and there seems little reason to think that they would exhibit a different habit in respect to game. Even supposing they followed till nightfall, they must surely lose touch with the herd after dark.

It appears probable that the tsetse-fly neither ranges the forest in search of its prey, nor follows it when encountered for any great length of time, but that it waits for the animal to come within the range of its perceptive powers. The fact that fly is constantly met with at the same spots* strongly suggests ambush rather than pursuit, and the writer has certainly no experience of having encountered fly in circumstances that suggested anything else.

The Maximum Distance at which the Fly can detect its Hosts.

Direct experiments are needed and planned to determine this point as far as possible. It appears necessary to distinguish between the maximum distance at which the fly readily perceives its prey, so that a man or animal would not pass by without being observed, and the distance at which it might locate say a herd of game grazing for several hours in one spot.

Some of the early explorers and hunters who encountered tsetse-fly were most emphatic that a very short distance might separate complete safety from certain death for their cattle, a narrow stream being sometimes mentioned as the dividing interval. Like other statements emanating from untrained observers this assertion, though undoubtedly greatly exaggerated, appears to have some foundation in fact. It would be possible to mention numerous personal observations of having been very

*The writer is aware that observations have been published of fly having been encountered in quantity at certain spots on one occasion and only in very small numbers at the next visit. During the wet season this is quite likely, as the fly is not confined by lack of shade, and when carried even for a short distance is hardly likely to return to exactly the same spot. Even in the dry season the passage of a herd of game might make a very material difference for a few hours, the hungry flies feeding and seeking seclusion, and the non-hungry males following the herd. Nevertheless, allowing for the difference in distribution in the wet and dry seasons, the statement is substantially correct.

little molested by fly on one side of a vlei, whereas on crossing to the other, some two hundred yards or so away, the party was immediately assailed by great numbers. A rather striking instance of the fly's limitations in this respect occurred in October 1919. The writer passed along a foot-path about 9 a.m. to examine a salt vlei near the Shangani for fly. None was seen till this vlei was reached and an hour was spent walking all round the margin, during which time only four tsetse were caught. Returning, the route taken aimed to cut the path at an acute angle, and when within 100 yards of the path on reaching a shady tree a number of tsetse suddenly attacked the party and " bit " with extreme voracity. Yet about an hour earlier the writer with his natives had passed within a hundred yards without being perceived. It cannot be proved definitely that the fly were there an hour earlier, but there was no spoor to indicate that any game had passed in the interim, and as the morning was hot the fly would hardly have crossed the leafless mopani to this particular tree. The writer was extremely impressed by this particular instance, and as a matter of fact the limitations in the fly's capacity for readily detecting a food supply has been a constant source of surprise throughout investigations now extending over ten years. A movement of fifty yards or so in a fly haunt frequently brings an accession in numbers of hungry insects and in numerous cases when all the flies seen were being collected, this phenomenon has been particularly marked. If it be accepted as an axiom that an animal or human being attracts all the hungry tsetse within a radius not exceeding the fly's powers of perception, then the limitations of the fly in this respect have been proved again and again ; for fresh hungry flies have undoubtedly been constantly encountered after a very short movement, whilst some two hundred yards or so has been found sufficient to keep a party comparatively free from attack whilst the fly swarmed that distance away. To mention another instance, in September 1913, the writer halted for breakfast on the south-east side of Sipane Vlei, between the Sengwa and Sassame Rivers in the Sebungwe district. A certain number of tsetse had been picked up *en route*, and the boys fetching water brought in more, so that a few bites were received. Some time after breakfast the writer took three natives to the north-west side of the vlei, some 300 yards away, and found the fly in numbers, some 87 being caught with one net in an hour. The wind was from the south-east and had been blowing over the party towards the fly haunts for at least two hours ; yet the bulk of the flies had not been attracted over this comparatively short distance, though they attacked the party in considerable numbers when their haunts were entered. Further visits to this spot have been made since, and it has been found that by camping on the south-east side of the vlei the attentions of fly could always in a great measure be avoided.

From the foregoing considerations it is believed that the tsetse-fly is only capable of readily detecting its hosts at a comparatively short distance, probably less than a hundred yards. It might, however, be longer in the wet season, when scent presumably carries further than in the dry.

If this limitation be proved, the fact increases the difficulty of accounting for the presence of fly in numbers in areas where large mammals are markedly scarce. It apparently remains to be proved, however, that fly occurs in numbers in any tract of country where large mammals are markedly scarce at all seasons of the year. If such a phenomenon does exist, the writer admits frankly that it appears irreconcilable with the theory of the vital association of the two forms of life.

Is it not possible that this limitation might account to some extent for the gregarious habit of the tsetse, the flies benefiting by the combined perceptive powers of a number instead of relying on those of single individuals? The value of numbers in regard to perception will hardly need urging upon anyone who has hunted antelope or other gregarious game.

The Following Distance of Female Flies.

It appears very important that attempts should be made to determine as accurately as possible the maximum distance to which female flies may be carried by game, man, etc. The point has a great bearing upon the question as to what would constitute an effective barrier to the fly's advance, and also upon the question of the fly as a whole migrating with game or moving about the fly area in company with its hosts. The writer has as yet been able to prove following on the part of the females up to only about 400 yards, although one instance has occurred where a specimen had *apparently* followed very much further than this, over a mile in fact. The observation in the latter case was, however, liable to considerable error. Some experiments in this connection were planned for the writer's visit to Sipane Vlei in August 1919, but could not be carried out owing to the unexpected scarcity of fly in that centre.

Sipane Vlei and some other Localities in 1919.

In a recent paper * the writer pointed out that the somewhat delicately balanced state of affairs which exists at the most favourable dry season haunts of the tsetse, namely the margin of vleis containing green grass in the dry season, is apparently liable to be somewhat easily disturbed by any agency tending to prevent game from visiting the vlei with its normal regularity. This disturbance, it was pointed out, would enhance the effect of game reduction by hunters, and might also have operated in the rinderpest epizootic, which undoubtedly induced abnormal movements of the panic-stricken remnants. These views have received some indirect support during the dry season of 1919, when for the first time since the rinderpest a reduction of fly in areas of the territory unaffected by civilisation has been recorded. This reduction is local, and extension since the previous year was recorded in one other part of the country, and may have occurred elsewhere. A reduction has been reported in the northern part of the Umniati fly area by Dr. Alec Mackenzie of Gatooma. Dr. Mackenzie's statement is to the effect that he found no fly at all in December 1919 in many parts where they are usually numerous near the Sakugwe and Umniati Rivers on the road from Gatooma to the Emerald Mine, and only a few finally at the headwaters of the Mvumvudzi and Urungwe Rivers, visited for the express purpose of locating the fly. There is, however, one spot where reduction can be proved on something like a mathematical basis, namely Sipane Vlei, lying between the Sengwa and Sassame Rivers in the Sebungwe district.

The rapidly-expanding Sebungwe fly area reached the Sengwa River from the west by 1910, and fly was first recorded at Sipane in 1913, though it may have been present at least a year earlier. In late September of that year it was present in great numbers, and 87 were caught with a net in one hour, in order to establish some sort of basis for

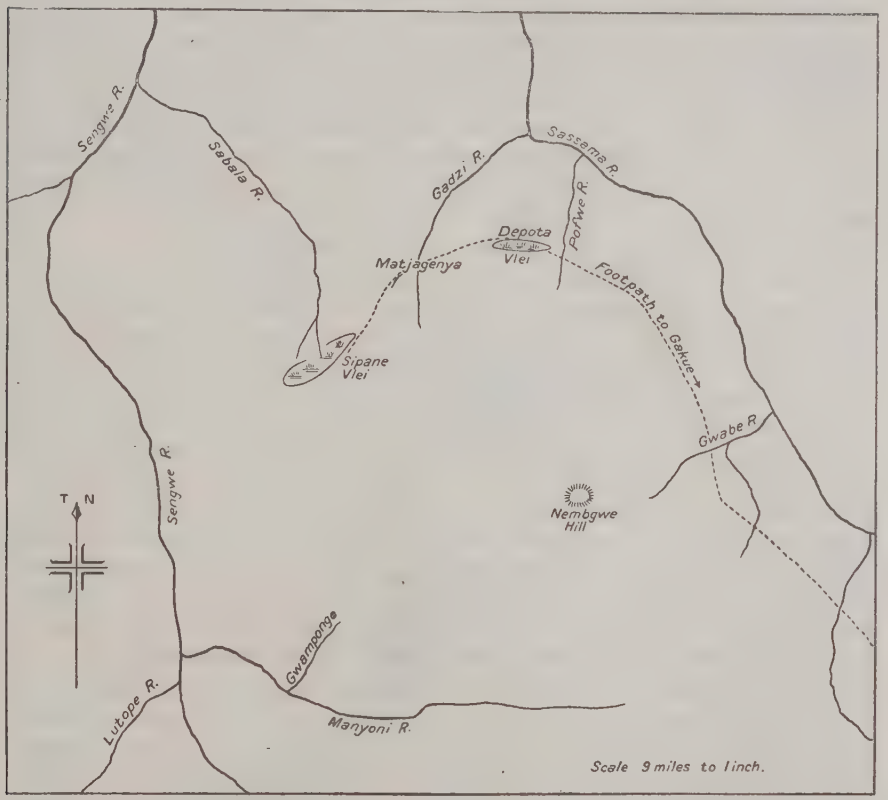
*Bull. Ent. Res. x, p. 83.

later observations. In November 1914, the flies in the vlei were " like a swarm of bees " around the individual who penetrated their haunts, and the ease with which pupae were collected during that visit has already been recorded. In August 1916, fly was extremely abundant, and living pupae could be found (some 30 were collected in a few hours), though the latter were not as abundant as in November 1914.* In late August 1919, the writer spent ten days at the vlei, for the purpose of chopping down the evergreen trees as an experiment. Hardly half-a-dozen fly were seen in the course of the day, where formerly they swarmed, and search for living pupae was entirely unsuccessful, notwithstanding that much more time was available than on previous visits. Only a few empty cases were found in the usual breeding places, and from these the flies had apparently emerged normally, there being no indications of parasitism.

In seeking a probable explanation of the decrease it was impossible to ignore the marked influence that the heavy rainfall of the two previous wet seasons had had on the country. The wet season of 1917–18 was the heaviest recorded since 1890–1, and was of a peculiar nature, the skies remaining overcast for weeks together, so that the maize crop suffered severely from excessive wet and lack of sunshine; conditions were thus ideal for maximum penetration. The following season's rainfall was also above the average. The first difference noted in the appearance of the country was the fact that the gusu (*Brachystegia*) forest bordering one side of the vlei had not yet lost its foliage, although quite leafless in August 1916 (see photograph, Bull. Ent. Res. x, p. 90, pl. ii, fig. 2). The same remark applied in a lesser degree to the thorn thicket (isi-nanga). The mopani, on the other hand, was practically leafless, except half-a-dozen trees in a wet situation on the edge of the vlei itself. These were in full leaf, having apparently grown out again since the fall. The gusu, it may be remarked, showed no young foliage and the leaves were falling sufficiently rapidly to show an appreciable diminution of shade during the ten days of the writer's stay. Careful inspection of the environment revealed a considerable extent of green grass to the south-west and west of the vlei, which was not in evidence during previous visits. Further, game was remarkably scarce in comparison with previous experience, and such as occurred was not feeding at the vlei itself, but on the green grass mentioned away from the vlei. With the exception of two small herds of impala, one kudu cow, one wart-hog, a rhinoceros, a wild dog and several duiker, no game was actually seen, in spite of daily excursions in all directions. Fresh spoor of a herd of zebra and another of sable was found in the vicinity. A lion drank one night at the vlei, as also did a solitary buffalo bull. This sounds a rather formidable list, but it represents the results of ten days exploration of the country within a radius of about eight miles of the vlei. A pack of wild dogs was apparently hunting the neighbourhood, and this may account to some extent for the scarcity of antelope, but the main point ascertained was that the few antelope present in the vicinity were not visiting the vlei for the purpose of feeding as is usually the case. They apparently found more attractive fare in the stretches of green grass away from the vlei (see sketch-map).

*In connection with the comparative smallness of the numbers quoted here and elsewhere it should be noted that no trained natives were available and that the pupae and flies were practically all collected by the writer personally.

Further evidence in support of the theory lies in the fact that fly was actually found more readily, though not at all abundantly, in the green grass areas away from the vlei, where such game as occurred was grazing, than at the vlei itself. The general prevalence of shade apparently rendered this possible under the prevailing conditions, although this is not usually the case at this time of year. A few fly were even met with in the gusu itself, which was unattractive to the majority of game, but only three were seen in a walk of several hours.



The obvious question is whether the fly had decreased from failure of the birth rate to equal or exceed the death rate, or from the majority having migrated. There was certainly no corresponding increase of fly within a radius of seven or eight miles of the vlei, as the country within this radius was thoroughly explored at the time. Nor had they shifted to the nearest known dry season haunt, which is Matjagenya on the Gadzi River, some seven miles away. There is no evidence of the appearance of fly at any point in this region outside the limits of the known area, and if the fly had migrated *en masse* in this direction it must have been noticed, as the country is inhabited. As a matter of fact the natives questioned stated that they knew of no fly outside the previously marked limit in this locality. It would appear, therefore that if the fly had migrated it must have moved back into the infested country

and for a distance exceeding the radius explored around Sipane Vlei. It is obviously possible that this may have occurred, but it appears very unlikely. Whatever be the correct explanation, it is certain that Sipane Vlei had ceased for the time being to serve the purpose it had served in the past, as a favourable breeding haunt for the fly during the latter part of the dry season. During the season of dispersion a considerable area of country would be affected by this fact.

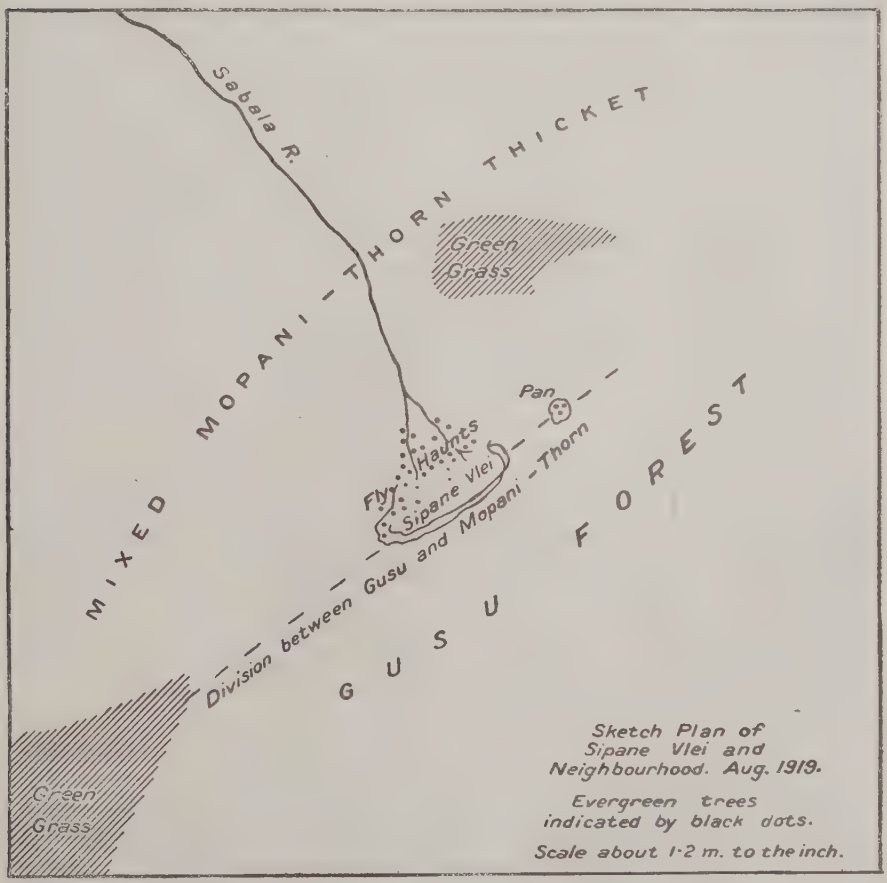
It is interesting to note that some years ago an experiment was planned in connection with Sipane Vlei with a view to determining whether the fly there was dependent upon the visits of big game or otherwise. The plan was to surround the whole vlei with a game-proof fence and thus keep the game away during the season of concentration. It was not carried into effect on account of the doubtful practicability of effective control at such a distance from communications. It would almost seem, however, as if meteorological conditions, in reducing the peculiar attraction of the vlei to game, had effected a demonstration instead. Unfortunately further observations bearing on this point will not be possible at this centre as the evergreen trees on the margin of the vlei have now been cut down.

Time was not available for a detailed inspection of other dry season haunts in the same region, but fly was scarce at the crossing of the Gadzi River, known to the natives as Matjagenya, on the way to Sipane, though formerly numerous. The natives resident at this point also bore out this observation. Again, at Depota Vlei some seven miles east of Matjagenya, no fly at all were seen, and some natives who had taken up their residence there the previous year had a number of apparently healthy dogs. They stated that they never saw fly near the vlei, although a very few were seen there by the writer in 1916. Winter shade is scarce at Depota, otherwise it would be a typical first-grade focus, as it is attractive to game as a rule. The writer has in the past seen eland, kudu, sable, impala, zebra, and sessaby in the vlei, and the fresh tracks of buffalo and rhinoceros in addition. In August 1919 only one duiker was seen in the neighbouring forest, and the tracks of three kudu. For the moment, therefore, the fly seems to be retrogressive rather than otherwise in this region, and it is essentially a region of isolated dry season haunts.

On the other hand, at the point where advance has been recorded definitely, namely up the Shangani River, the region is one of diffused dry season haunts (second and third grade foci), and game was very plentiful in October 1919, though their numbers had doubtless been augmented owing to the organised shooting further down the river which commenced in June. Here then we have an illustration of " the fly following the game," only as the area of increase is some ninety miles, as the crow flies, from Sipane Vlei the fly can hardly have migrated thither. The presumption is that conditions the previous year favoured breeding in the one area, and were unfavourable in the other.

Whilst conditions in the northern part of the Umniati fly area have no doubt been affected to some extent by the efforts of hunters in shooting game for the " Emerald " and " Copper Queen " Mines, and the portion to the east of the river considerably affected on account of being in the open shooting area, the writer has been, so far as is known, the only European visitor to Sipane Vlei for several years past.

It is not claimed that the only way in which one or two abnormally heavy wet seasons could affect the tsetse-fly lies in inducing a wider distribution of water and attractive grazing during the dry season. The involved interrelationship between the tsetse fly, its diseases and enemies, the enemies of its enemies, and so on, is almost a closed book at present, and this interrelationship is no doubt affected in some degree by the season. It is only intended to point out a possible explanation of the observed phenomenon as a basis for future research. The abnormally heavy rains of the past wet season have certainly affected the appearance of some parts of the country in the dry season to a marked degree, and the fly has undoubtedly decreased in certain areas, one of which at least, as the writer has endeavoured to show, has also been affected by the increased rainfall.



Curiosity naturally suggested reference to the records of rainfall in the territory with a view to ascertaining whether any record of one or two seasons of exceptional severity preceded any definite information concerning reduction of fly. The available rainfall statistics unfortunately date no further back than 1888 and in the

intervening period there is only one record of two consecutive wet seasons comparable with those of 1917–18 and 1918–19. These are the seasons 1889–90 and 1890–1. The total fall in these two seasons at Bulawayo considerably surpassed that of the recent two seasons, the number of inches recorded being 87·81 in the earlier couplet against 76·13 for the later. Was this heavy fall followed shortly by any marked reduction of tsetse ? There is some suggestion to the effect that it was, at least in certain parts of the territory, although it is of such an indirect and unsatisfactory nature that it is practically valueless.

It is curious, however, that during this very time, a marked recovery from a period of decrease seems to have taken place in the region of the Zambesi. In a foot-note to a paper by the writer (Bull. Ent. Res. v, p. 100), Captain Selous' opinion is recorded that by 1888 " the belt shown to the west of the Victoria Falls had disappeared," and " that much of the fly to the east of the Falls had also gone by that date." This statement was doubtless substantially true in 1888, in fact there is other evidence that fly was decreasing in this area during the preceding years (v. Dr. Holub, Austen's Monograph, p. 203). Nevertheless Selous' statement is misleading and should be corrected in case other investigators may use it as a basis for argument. The writer has first-hand information to the effect that fly was numerous between the Falls and the Zambesi-Chobe confluence in 1893, and it is apparent that an increase of fly took place subsequent to 1888. The first-hand evidence referred to is contained in a report by Mr. A. Giese, Cattle Inspector, to the Chief Veterinary Surgeon, Salisbury, dated 9th July 1918. The report is worth quoting in full, although some of the matter does not bear on the present argument. It appears that the fly did actually disappear from this part of the country at the time of the rinderpest, whatever may have been the position of affairs near the Limpopo.

Mr. Giese's report is as follows :—

" 9.vii.1918. The following notes are reminiscently penned because they may serve as a guide as to where to expect the tsetse-fly, now re-appearing west of the Gwaai,* to spread to should this re-appearance be only a return to localities driven out from or killed by the rinderpest, and not as well to localities which the fly had already voluntarily disappeared from before the rinderpest arrived.

" In 1861–2 Baldwin(?) brought the first waggons to Deka commencing the track which eventually grew into what is now known as the Pandamatenga or western border road. He had to leave his wagons at Deka and proceed to the Zambesi on foot as the intervening country was infected by fly.

" Somewhere about the middle seventies Geo. Westbeach established his later far-known trading station at Pandamatenga, when the fly had receded further north somewhere north of Gazume Vlei. At the same time, or a little later, transport could be taken to the Victoria Falls and to Bingua Spruit—about railway cottage 277—from where Westbeach's waggons used to fetch grain traded in the fly-infested country to the east ; also that broken stony country north of the present Matetsi siding was believed to be free from fly right up to Victoria Falls.

* No fly has as yet been found west of the Gwaai, but outbreaks of trypanosomiasis have occurred during the past three wet seasons.

" In July 1893, the writer's first appearance in these parts, ox transport was left at Gazuma, but fly was found between Leshuma and Kazungula, Chobe and Zambesi junction, and from Kazungula right up the Chobe and right down to within a few miles of the Victoria Falls, fly being particularly aggressive on the latter stretch.

" In 1894–5 during various trips to what is now the Wankie Colliery all animals had to be left at Deka ; in fact when the writer pegged the present Deka farm in 1895 animals were not allowed near its S. E. beacon.

" During these latter years the southern boundary of the fly area ran roughly from Galobe—Gwaai junction more or less west but north of that open park-like country round and to the south of Chumagu Malishi and Makolo to places near the present Kennedy's Halt, and hunters used to take their ox waggons thus far north.

" At the end of 1897 the writer took a horse up the Chobe and in 1898 six spans of donkeys to the present Wankie Coal Mine, all fly having disappeared then."

In answer to direct queries by the Chief Veterinary Surgeon Mr. Giese replied as follows under date 30.vii.1918 :—

1. " *What species died of rinderpest* ?

" Eland, buffalo and kudu principally, and in the order mentioned as regards numbers found dead and the occurrence of the species at the time. The greater mortality among the eland was not due to their being more susceptible to disease but to their occurring in much greater numbers than the other game. This they still do. Of other game reedbuck probably suffered most.

2. " *What was the rate of mortality ; were there any survivors* ?

" In 1898 the only surviving buffalo, between Kazungula and the Gwaai were one bull, 3 cows and 3 calves, running 7 miles west of the present Colliery, and a somewhat similar number on the lower Inyantue ; which means that these were the only buffalo left in Matabeleland west of the Gwaai, because their habitat did coincide with the tsetse-fly.

" What the number of buffalo was in pre-rinderpest days one cannot say, as they were scattered owing to the natives carrying guns ; but the increase of these 7 animals (survivors) is a fairly compact herd of some seventy animals now confining themselves to a belt of country 20 miles by 30 miles to the west of the railway. The Inyantue herd is a little larger.

" There were stray survivors of kudu and they also have more than recovered owing to the absence of firearms ; there are more kudu than any other antelope, Sharpe's steinbuck excepted, in the broken and hilly part of the Wankie District.

3. " *Did the fly disappear at once* ?

" The writer left Deka on 15th January, 1896, when fly were as stated in his notes, arrived in Bulawayo mid-February and was sent for from the C. C's office to give an account of what he knew of rinderpest which was then approaching. When he returned after the Rebellion in 1897 the fly had disappeared."

The record is extremely interesting in showing that fluctuations in the distribution of fly on a moderately extensive scale have occurred in the past apart apparently from overwhelming game destruction, although the hunters appear to have been of opinion that the decrease of fly during the period preceding 1888 was due to their

inroads into the number of buffalo. As a matter of fact, events in this region seem to have contributed largely to the solidifying of Selous' opinion that the fly was dependent upon buffalo.

The rainfall in the Zambesi valley frequently differs very considerably from that in the remainder of the territory, and it is unfortunate that no records in this area for the period concerned appear to be available.

The records, are however, instructive in regard to the influence of a series of seasons of low rainfall. At Kariyangwe in the Sebungwe district the rainfall recorded for the three seasons 1909–10, 1910–11 and 1911–12 was extremely low. This station was then closed down, but referring to the Wankie records, somewhat further from the scene, we find that the next two years were also very low indeed. During this period the extension of the Sebungwe fly area proceeded at its maximum speed, as may be seen by a glance at the author's map (Bull. Ent. Res. x, map 1). The records of advance in this area are moderately accurate as regards the three year intervals marked on the map, with the exception of the north, where the discovery of tsetse-fly on the lower Sengwe River in 1913 indicated that the previous limits in this area, visited only at long intervals by officials who traversed the country rapidly, were probably faulty. It is not possible, however, to obtain accurate yearly records. The dry season of 1913 was remarkable for advance in almost every direction, excluding a portion of the western limit where the fly appears to have reached the division between favourable and unfavourable country. The rains were very late in 1912, no serious showers falling until near the middle of December. Dry season conditions were thus unusually prolonged, and it is believed that such conditions favour increase of fly.

To recapitulate, whilst the writer is far from attaching any exaggerated importance to these limited records, they are certainly suggestive of abnormally heavy wet seasons having a deleterious effect on the fly in certain areas, and of a series of seasons of low rainfall, especially if late, favouring increase. Intense and prolonged dry season conditions, such as occur during a cycle of years of low rainfall, are judged to favour the fly at centres which resist the action of drought best, owing to the consequent concentration of game. A rise in the water-table after an exceptionally heavy season or two causes a disturbance in the usual conditions by inducing a more general distribution of good grazing and water throughout the country, and a proportionately reduced attraction of the " focus " to game.

It is much to be regretted that the writer's itinerary in 1918 did not include Sipane Vlei. The tremendous rains of the 1917–18 season had a very marked effect on the forest lying between the railway line and the Gwaai River on the western side of the territory, and it is reasonable to suppose that conditions at Sipane Vlei may have been similar to those in 1919, seeing that at Gokwe, the nearest meteorological station, 43·03 inches fell in the 1917–18 season and 33·10 inches the 1918–19 season, although even the latter is well above the normal for that district. If the writer's theory is correct, fly should have been numerous and hungry in the dry season of 1918, pupae being, however, scarce, resulting in a great diminution of fly by 1919.

This theory is very much in accordance with observations published by Lloyd (Bull. Ent. Res. vii, pp. 67–79) with reference to Northern Rhodesia. Lloyd draws

a most necessary distinction between apparent and real abundance of fly, and shows how the percentage of females caught in the ordinary way varies in inverse ratio, and the number of pupae secured in direct ratio, with the abundance of game. Here we have direct observations indicating that scarcity of game induces hunger and hunger inhibits breeding. Both these observations have received support from other investigators, including the comparatively scanty observations in this territory, and appear to be in a fair way to become established. If this proves to be the case the effect of hunting in the early days in the Transvaal and the apparent effect of the rinderpest would appear to be quite comprehensible, in spite of the fact that the game was not completely eliminated in either case.

The result of a heavy reduction of game would seem to follow logically, quite apart from complete elimination, namely irregular meals at long intervals—perhaps some individual starvation—in any case a greatly reduced birth rate. If the birth rate were checked at all suddenly, especially during the season of concentration when the larvae are deposited within a limited area, the fly's parasites might be expected to destroy a much higher percentage than before. The writer is very much in agreement with Duke's contention as to the probable effect of a sudden or " cataclysmic " change in the distribution and numbers of game animals. The local distribution of *G. morsitans* in relation to the habits of game animals, even during the time of year when the fly is dispersed, is frequently very marked. In this way it appears that the effect of shooting and of the rinderpest might be explained, but it is only comprehensible on the supposition, which the writer believes to be justified, that the fly's ability to perceive its hosts is strictly limited, that it is incapable of following up a trail for any great distance by scent and of attaching itself to and keeping in touch day after day with such game as may be present in the infested area. In the latter part of the dry season its limitations in locating game, except such as may visit its haunts, seem to be obvious, and if, as is probable, this is one of the most important breeding periods, the effect of both shooting and rinderpest seems clear enough.

It may seem improbable that a species of insect should be so ill-provided for taking care of itself under varying conditions as the views outlined in this paper suggest, but if there is one thing more striking than another about the tsetse it is just this disability to adapt itself to a change in its environment, otherwise it would not have retreated before the advance of civilisation, in the absence of any direct effort to drive it back.

Summary.

In the foregoing pages the following tentative views have been put forward in the hope that they may receive either confirmation or criticism from other investigators :

(1). The latter part of the dry season is probably, in general, the most favourable portion of the year to the fly.

(2). The later the onset of the rains the greater the capacity for increase.

(3). Seasons of unusually heavy rainfall are inimical, at least in certain areas.

(4). A series of years of low rainfall is favourable.

(5). Regions where the fly commonly attains the greatest concentration of numbers are the regions where it is most liable to be reduced or to die out, namely, parts of the infested areas where first-grade foci predominate.

(6). In Southern Rhodesia the passage of grass fires has, as a rule, no appreciable effect on the numbers of the fly.

(7). Mopani belts are probably of considerable value to the fly in providing limited areas attractive to game in the wet season, where the grass remains short; they possibly also afford a convenient refuge from grass fires in the dry season.

(8). The fly does not migrate under the stimulus of hunger or in company with game.

(9). The fly as a whole does not follow game about infested areas.

(10). The maximum distance at which a hungry fly readily detects its hosts is a short one, possibly less than 100 yards.

(11). The maximum following distance of the females remains to be determined; the writer is not yet convinced that the females seek animals and human beings only for the purpose of feeding, though this appears probable.

NOTES ON THE MOSQUITOS OF MADAGASCAR, MAURITIUS AND RÉUNION.

By F. W. Edwards,

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Through the kindness of Mons. E. Séguy, of the Muséum d'Histoire Naturelle, Paris, I have recently been enabled to examine a considerable number of mosquitos from Madagascar and the neighbouring French islands, including the types or co-types of all the species described from Madagascar by Ventrillon. As the examination of this material has disclosed the existence of several species hitherto unrecorded from these islands, as well as some new synonymy, it has been thought desirable to record the results at once. In the following pages all the species of mosquitos hitherto known from this region are dealt with. The total number is only 28, as compared with about 180 in the African fauna, so that it is highly probable that further collecting would produce many others.

Anopheles mauritianus, Daruchy de Grandpré & d'Emmerez de Charmoy.

Ambatofanghera and Ambohipomana (*Bouet*, 1905); Tananarive (*Neiret* and *Ventrillon*, 1904 ; *Bouet* 1905).

The commonest *Anopheles* in Mauritius, according to d'Emmerez.

Anopheles maculipalpis, Giles.

Occurs rarely in Mauritius (*d'Emmerez de Charmoy*).

Anopheles squamosus, Theobald.

Cellia tananariviensis, Ventrillon.

According to Ventrillon this is by far the commonest *Anopheles* in Madagascar and his statement is certainly borne out by its abundance in the collections which I have examined. No constant difference was observable between Madagascan and African specimens.

Anopheles pharoensis, Theobald.

A single specimen, much damaged but undoubtedly this species, from Tananarive (*Ventrillon*, 1905).

Anopheles funestus, Giles.

Four females from Moratsiazo, Lac Itasy (*Bouet*, 1904).

Anopheles marshalli, Theo.

Females from Tananarive (*Neiret*, 1904, and *Ventrillon*, 1905) and Ambohipomana (*Bouet*, 1905).

Anopheles transvaalensis, Carter.

Two females from Tananarive (*Bouet*, 1905).

Anopheles costalis (Loew) Theobald.

Females from Mauritius, where, according to d'Emmerez, the species is common, are in the Paris Museum.

Aëdes (Stegomyia) albopicta, Skuse.

Stegomyia lamberti, Ventrillon, Bull. Mus. Paris, x, p. 552 (1904) and Arch. Parasit. ix, p. 441 (1905).

Stegomyia scutellaris, Theobald et auct. (*nec* Walker).

Ventrillon's types included both sexes, so that the identification of *S. lamberti* is beyond doubt, notwithstanding the fact that Ventrillon states that the female claws are toothed, whereas in all specimens I have examined they are simple. Either Ventrillon made a mistake, or the species is variable in this respect, which is not unlikely.

This species also occurs at Réunion as shown by specimens in the Paris Museum, collected at St. Denis, v-vi, 1913 (*Surcouf*). It has been recorded from Mauritius, where it is said to be very common (*d'Emmerez de Charmoy*). It is surprising that it does not seem to occur on the African mainland, since it has such a wide range throughout the Oriental region.

Aëdes (Stegomyia) argenteus, Poiret (*fasciata*, Fb.).

Culex insatiabilis, Bigot, Ann. Soc. Ent. France, (3) vii, p. 118 (1859).

Bigot's description and figure can apparently only apply to this species, which is common on the islands, especially near the coast (*d'Emmerez de Charmoy*).

Aëdes (Skusea) cartroni, Ventrillon.

Stegomyia cartroni, Ventrillon, Bull. Mus. Paris, xii, p. 143 (1906).

This species, which I had not previously seen, evidently belongs to the sub-genus *Skusea*, although the male is unfortunately unknown. It is very close to *S. pembaensis*, the type of the subgenus, so close indeed that it may eventually prove to be a variety only. However in all the examples of *S. pembaensis* received at the British Museum the abdomen is unbanded dorsally, and the scutellar scales are black, while in the few specimens of *S. cartroni* sent the abdominal segments have narrow pale basal bands, and the few remaining scutellar scales are white.

Aëdes (Ochlerotatus) nigeriensis, Theobald.

Culex fowleri, d'Emmerez de Charmoy, Ann. Trop. Med. ii, p. 258 (1908).

Mr. H. F. Carter informs me that he has examined a male of *C. fowleri* from Mauritius, and established its identity with *O. nigeriensis*, which was already suggested by the author's allusion to the two pale spots on the sixth abdominal tergite of the female.

A female in the Paris Museum from Madagascar may be either this species or *O. fryeri*, Theo.

Orthopodomyia arboricollis, d'Emmerez de Charmoy.

Culex arboricollis, d'Emmerez de Charmoy, Ann. Trop. Med. ii, p. 257 (1908).

Newsteadina arboricollis, Theobald, Ann. Trop. Med. ii, p. 297 (1908).

This species, which is so far only known from Mauritius, is a typical *Orthopodomyia*. I have examined the types in the Liverpool School of Tropical Medicine and find that the female has the very short fourth tarsal joint on the front and middle legs, characteristic of this genus, while the male hypopygium is very similar to that of the other species.

Taeniorhynchus (Mansonioides) uniformis, Theobald.

Females of this species in quite recognisable condition from Ambatofanghera (*Bouet*, 1905). Other specimens, probably of *T.* (*M.*) *uniformis*, were from Morouslava (*Dr. Petit*, 1901).

Taeniorhynchus (Coquillettidia) flavus, Ventrillon.

Culex flavus, Ventrillon (*nec* Motschulsky), Bull. Mus. Paris, x, p. 550 (1904).

Culex grandidieri, Blanchard, Les Moustiques, p. 627 (1905).

Several females, including cotypes of Ventrillon, from Tananarive (*Dr. Ventrillon*, 1905).

This is very close to the African *T. fuscopennatus*, of which it may be a mere local form; the hypopygia are very similar, as is shown by a drawing taken from Ventrillon's male cotype which M. Séguy kindly sent me; this indicates the clasper as having a rather different shape. *T. flavus*, however, in all the examples I have seen, is readily distinguishable by the coloration of the scales on the wing, particularly the apical half. The costa is yellow, with a line of black scales on the outer margin on its basal two-thirds; subcostal and first longitudinal veins predominantly yellow, apically entirely so; stems of fork-cells and tips of veins round wing-tip yellow; remaining veins and fringe mainly black. This description is considerably at variance with that of Ventrillon, but an examination of the cotypes showed that his was inaccurate.

T. fuscopennatus differs in having the dark and light wing-scales fairly evenly mixed, and also in having the integument of the thorax blackish or dark brown, that of *T. flavus* being light brown.

T. aureus, Edw., has an almost greater resemblance even than *T. fuscopennatus*, but it again has a rather differently shaped clasper, and has the costa entirely yellow.

I have adopted the name *flavus* rather than *grandidieri*, because the *Culex flavus* of Motschulsky is probably an *Aëdes*, Ventrillon's later *flavus* being therefore valid in the genus *Taeniorhynchus*.

Culex ventrilloni, sp. n.

♀. *Head* scales narrow, blackish; a rim round the eyes and a longitudinal band down the middle pale golden. Proboscis with a distinct yellow median ring, broader below than above. Palpi one-fourth as long as the proboscis, black, with some white scales about the middle. *Thorax* blackish brown, bristles dark. Prothoracic lobes with a few narrow golden scales; mesonotum with golden and dark brown scales, the former occurring in an indefinite line in the middle and in some large

rather irregular patches on each side on the front half. Scutellum pale, with narrow pale golden scales. Pleurae with four or five small patches of pale ochreous flat scales. *Abdomen* dark brown, tergites with white basal lateral patches and ochreous basal bands, which are broadest in the middle ; sternites with dark apical bands. *Legs* black ; all the femora black to the base above, ochreous beneath on the basal half. Femora and tibiae all with conspicuous whitish tips, no scattered pale scales. Tarsal joints conspicuously ringed with ochreous at the base only ; the rings on the last two joints very narrow. Claws simple ; empodia large, nearly as long as the claws. *Wings* with brown scales, those in the lateral series linear. First fork-cell more than twice as long as its stem, its base nearer the base of the wing than that of the second. Cross-veins separated by rather more than the length of the posterior.

Length, 6 mm.

MADAGASCAR : Tananarive, 1904, 1 ♀ (*Dr. Neiret*) and 1905, 2 ♀ (*Dr. Ventrillon*). *Type* in the Paris Museum ; paratype in the British Museum.

This species is noteworthy for the ornamentation of the head, the basally ringed tarsal joints, and the large empodia. It has no near ally among the described African and Oriental species, and in the absence of the male it is impossible to say in what subgenus it should be placed. Possibly it may be a *Lutzia*.

Culex annulitarsis, Macquart.

The brief description of Macquart will not apply to any known species. It was referred by Theobald to the synonymy of *Stegomyia fasciata*, but Macquart's description of the legs (hind tibiae with a broad white ring before the tip ; hind metatarsi white, with a narrow black ring) makes the reason for this far from obvious.

Culex (Lutzia) tigripes, Grandpré & Charmoy.

Tamatave (*Jaillet*). Described from Mauritius.

Culex (Culex) quasigelidus, Theobald.

Pseudoheptaphlebomyia madagascariensis, Ventrillon.

This synonymy, previously given by me, can be confirmed from an examination of the types, although Ventrillon's description does not agree. Additional specimens are from Ambohipomana (*Bouet*, 1905) and Tananarive (*Waterlot*, 1916).

Culex (Culex) giganteus, Ventrillon.

Culex giganteus, Ventrillon, Bull. Mus. Paris, xii, p. 100 (1906).

Culex neireti, Ventrillon, Bull. Mus. Paris, xii, p. 103 (1906).

The original description of *C. giganteus* and *C. neireti* are very similar, except as regards the size given and the markings of the thorax. Study of the types shows that the insects are actually the same, the differences in the description being due to inaccurate observation. In particular, Ventrillon's measurement of 10 mm. body length for *C. giganteus* is a considerable exaggeration, the actual length being only about 6 mm., excluding the proboscis. Additional specimens are from Ambatofanghera and Ambohipomana (*Bouet*, 1905).

The species is a close ally of the African *C. annulioris*, Theo., differing chiefly in the greater extension of the yellow markings of the abdomen ; and in some small details of the structure of the male hypopygium, notably the shorter and stouter

basal arms of the tenth sternites. Perhaps the single specimen of *C. annulioris* recorded by d'Emmerez de Charmoy (Ann. Trop. Med. ii, p. 260) may have been *C. giganteus*.

Culex (**Culex**) **sitiens,** Wied.

Culex ronaldi, d'Emmerez de Charmoy, Ann. Trop. Med. ii, p. 259 (1908).

Recorded from Mauritius, but not from Madagascar, where however it is very likely to occur, since it has a wide distribution from East Africa to Australia.

Culex (**Culex**) **univittatus,** Theobald.

Heptaphlebomyia montforti, Ventrillon, Arch. Parasit. ix, p. 448 (1905).

My previous statement as to the identity of *C. univittatus* and *H. montforti* is confirmed by an examination of the male hypopygium of one of Ventrillon's specimens.

Culex (**Culex**) **pipiens,** L.

Tananarive (*Neiret*, 1904 ; *Ventrillon*, 1905).

This record forms a further notable extension of the known range of this species, which until recently was thought to be confined to the temperate regions of the northern hemisphere. It is now known also from South and East Africa and from the Argentine.

Culex (**Culex**) **? laurenti,** Newstead.

Some female specimens from Tananarive (*Neiret*, 1904) are perhaps this species, though it is possible that they may belong to the variety of *C. pipiens* with an unbanded abdomen, which is known from East Africa and from the Mediterranean region.

Culex (**Culex**) **fatigans,** Wied.

Culex cartroni, Ventrillon, Bull. Mus. Paris, xi, p. 429 (1905).

Culex anxifer, Bigot, Ann. Soc. Ent. France, (3) vii, p. 117 (1859).

The hypopygium of Ventrillon's type male was mounted and proved it to be this species. Other specimens from Réunion (*Surcouf*). The commonest mosquito in Mauritius (*d'Emmerez de Charmoy*).

Bigot's description of *C. anxifer* is unrecognisable, and he had no type, but Blanchard has referred his name to the synonymy of *C. fatigans*, and there seems no sufficient reason to dispute this.

Culex (**Culex**) **argenteopunctatus,** Ventrillon.

Heptaphlebomyia argenteopunctata, Ventrillon, Arch. Parasit. ix, p. 446 (1905).

Heptaphlebomyia kingi, Theobald, Ann. Trop. Med. vii, p. 601 (1913).

A number of females, all in poor condition, some barely recognisable, from Tananarive (*Ventrillon, Bouet, Guérin Méneville, Waterlot*).

A male in the British Museum named by Ventrillon lacks the abdomen, but fortunately there is another, in perfect condition, from the Gold Coast (*Dr. A. Ingram*). I have mounted the hypopygium of this and find that it is a true *Culex* bearing a rather considerable resemblance to *C. decens*, Theo. The two silvery spots on the thorax are remarkable and absolutely diagnostic, being comparable only with certain species of *Aëdes*, e.g., *punctothoracis*, Theo.

Uranotaenia neireti, sp. n.

♂ *Head* scales and integument blackish, a spot of pale blue in the middle in front, and another on each side at the eye-margin. Proboscis slightly longer than the abdomen, slightly swollen at the tip. *Thorax* brown, lower half of pleurae somewhat lighter. Prothoracic lobes with light blue scales; proepimera bare, lower half blackish. Mesonotum with narrow dark brown scales, those on the scutellum flat; no lateral line of flat scales. A spot of pale blue scales in middle of pleurae, and a few more scattered on sternopleura; integument darker on each side of the blue spot. *Abdomen* dark brown above, lighter brown beneath. *Legs* dark brown; coxae and bases of femora ochreous; tip of third and whole of fourth tarsal joint of hind legs whitish; fifth darker. Tarsi and claws normal. *Wings* with brown scales only, those towards the apex rather narrowly spatulate. Upper fork-cell more than half as long as its stem.

Length, 3 mm.

MADAGASCAR: 1 ♂ 1 ♀ (*Dr. Ventrillon*), without exact locality, labelled "*Ficalbia neireti*. Type: Ventr." Type ♂ in the Paris Museum. The female and a second male from Tananarive (*Ventrillon*, 1905) have the blue scales replaced by greyish white, probably owing to fading.

Eretmopodites quinquevittatus, Theobald.

Eretmopodites condei, Ventrillon, Arch. Parasit. ix, p. 144 (1905).

No males were present, and the few females in Ventrillon's collection were rather rubbed, but the above synonymy, previously suggested by me, is highly probable.

NOTES ON THE NOMENCLATURE OF CERTAIN AFRICAN TABANIDAE (SUB-FAMILY PANGONIINAE), WITH DESCRIPTIONS OF A NEW GENUS AND NEW SPECIES.

By Major E. E. Austen, D.S.O.

Some six years ago, it was correctly pointed out by Brèthes (Bull. Soc. Ent. de France, 1914, p. 59) that the generic designation *Diatomineura*, Rond. (Archiv. Zool. Anat. Fisiol. iii, p. 84, 1864), is a synonym of *Osca*, Walk. (Ins. Saund., Diptera, Part i, p. 10, 1850—*nec* Walk., 1864, *nec* Stål, 1871). The first species mentioned by both Walker and Rondani is *Pangonia depressa*, Macq. (=*Erephopsis lata* (*Tabanus latus*), Guér.), and this species is designated by Brèthes as the genotype. *Erephopsis lata*, Guér., of Kertész's Catalogus Dipterorum (iii, p. 165, 1908), must therefore be known henceforth as *Osca lata*, Guér., and the South African *Tabanus barbatus*, L. (*Pangonia barbata*, Auct.), and *Pangonia fulvifascia*, Walk., must be transferred to the genus *Osca*.

It is not, however, simply a question of substituting *Osca* for *Diatomineura*, since *Osca lata*, Guér., is certainly not congeneric with any, or at any rate with the majority of the species at present grouped under *Diatomineura*, sub-genus *Corizoneura*. So far as regards Ethiopian and Oriental species, the difficulty can be met by, as is hereby proposed, raising *Corizoneura*, Rond. (*loc. cit.*, p. 85) to generic rank, designating as its genotype the first species mentioned by Rondani under *Corizoneura*, viz., *Tabanus aethiopicus*, Thunb. (syn. *Pangonia appendiculata*, Macq.), and erecting a new genus, which may be termed *Buplex*,* for certain Ethiopian species included by Kertész under the *Corizoneura* division of *Diatomineura*, but not congeneric with *C. aethiopica*, Thunb. The arrangement indicated may be expressed in tabular form as follows.

Eyes bare; first posterior cell open.

Ocelli absent; face, especially in ♀, markedly produced (forming a snout-like prolongation), with a shining callus, or at least a more or less shining area, on each side; proboscis long or very long, usually much longer than thorax including scutellum, and generally horizontal or nearly so; distal extremities of first and second joints of front tarsus in ♂ generally each produced above into a tongue- or lappet-like process, which, in case at least of second joint, is often of considerable relative length .. .. *Corizoneura*, Rond.

(Genotype, *Tabanus aethiopicus*, Thunb.,—syn. *Tanyglossa aethiopica*, Thunb.; *Pangonia appendiculata*, Macq.).

Ocelli usually present; face not produced, merely convex, and without shining callus or area on each side; proboscis of only moderate length, shorter than or about as long as thorax including scutellum, and generally slanting downwards at an angle of 45°; distal extremities of tarsal joints never produced .. .. ..

Buplex, gen. nov.

(Genotype *Pangonia suavis*, Lw.).

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* βου-πλήξ ὁ, an ox-goad.

Among other species referable to the new genus thus briefly characterised are *Pangonia brunnipennis*, Lw., *P. subfascia*, Walk., *Corizoneura albifacies*, Ric., *C. dissimilis*, Ric., and the new species described below.

The genus *Corizoneura*, Rond., as defined and restricted above, includes, in addition to the genotype and the new species described in this paper :—*Diatomineura virgata*, Austen ; *D. inornata*, Austen ; *D. neavei*, Austen ; *Pangonia sagittaria*, Surc.; *Corizoneura distincta*, Ric. ; *Pangonia lateralis*, Wied. (Fabr. ?) ; *Diatomineura hastata*, Austen ; *D. lineatithorax*, Austen ; *D. penetrabilis*, Austen ; *Corizoneura pallidipennis*, Ric. ; and *C. umbratipennis*, Ric. The foregoing all belong to the Ethiopian Region, and congeneric with them are the Oriental *Pangonia taprobanes*, Walk. (syn. *P. rufa*, Macq.), and *P. longirostris*, Hardw.

Another change which may as well be made now, since in any case it is almost certain to be effected sooner or later, is the replacement of Macquart's generic designation *Cadicera* by *Phara*, Walk. (Ins. Saund., Diptera, Part i, p. 9, 1850). The latter name, accompanied by a brief diagnosis, was applied by its author to one of " several groups or subgenera " of *Pangonia*, Latr. ; eighteen species were mentioned under *Phara*, the first three of these being, in the order given, *Pangonia melanopyga*, Wied., *P. chrysostigma*, Wied., and *P. crassipalpis*, Macq. The present writer hereby proposes to regard *Pangonia melanopyga*, Wied., as the genotype of *Phara*, Walk. ; to raise the latter to generic rank ; and to restrict it so as to include besides the genotype, among the species mentioned under *Phara* by Walker, only *Pangonia chrysostigma*, Wied., and *P. crassipalpis*, Macq., since these three species are obviously congeneric. *Phara*, Walk., therefore, as thus restricted, replaces and must be substituted for *Cadicera*, Macq. (Mém. Soc. Imp. des Sc. Lille, 1854, (2) p. 42, 1855), founded for *C. rubramarginata*, Macq. (*loc. cit*, p. 23).

Except where otherwise stated, the types of the new species described in the following pages are in the British Museum (Natural History).

Genus **Buplex,** nov.

Buplex fuscinervis, sp. n.

♀.—Length (2 specimens) 12 to 13 mm. ; width of head 4 to 4·2 mm. ; width of front at vertex 0·8 mm. ; length of proboscis 3·4 to 3·5 mm. ; length of wing 12·4 to 12·5 mm.

Body, except certain areas at sides of abdomen, black above, with scutellum, lateral borders and three narrow longitudinal stripes on scutum, and deep posterior borders to abdominal segments smoke-grey or pale smoke-grey pollinose ; lateral extremities of tergites of first (visible) and second abdominal segments smoke-grey, more or less tinged with ochraceous tawny owing to the subjacent ground-colour ; wings with base, costal and sub-costal cells and stigmatic area ochreous, veins after first longitudinal in distal half (from base of discal cell onwards) dark brown, and for most part more or less strongly suffused with mummy brown.*

*For names and illustrations of colours used for descriptive purposes in the present paper, *see* Ridgway, " Color Standards and Color Nomenclature " (Washington, D.C. Published by the Author, 1912).

Head : ocelli present ; face, jowls and lower half of front light buff pollinose, clothed with pale yellowish hair, occiput smoke-grey pollinose, and likewise clothed with pale yellowish hair ; upper part of front with a pair of narrow, blackish stripes, commencing at ocellar tubercle, descending somewhat lower than middle and diverging below, each stripe clothed with short, curving black hairs, interspersed with some glistening yellowish hairs ; *palpi* clothed with yellowish hair, longer on proximal than on terminal joint, latter russet or ochraceous tawny, proximal joint mouse-grey, russet towards distal extremity ; first and second joints of *antennae* clothed partly with yellowish hair, partly with black hair, first joint mouse-grey or deep neutral grey, second joint russet (third joint missing in case of type). *Thorax*: smoke-grey longitudinal stripes on dorsum extending from front to hind margin of scutum, confluent posteriorly ; transverse suture smoke-grey, forming a connection between lateral border and outer smoke-grey stripe on each side ; pleurae and pectus light greyish olive pollinose ; thorax clothed with yellowish hair, black stripes on dorsum clothed posteriorly with fine black hair. *Abdomen* : black area on first (visible) and second tergites restricted to a transverse band occupying middle third of anterior half, with rounded posterior angles in each case, and, especially on second segment, indented in middle line behind ; lateral margins of fourth and following tergites, and lateral extremities of hind border of third tergite ochraceous tawny, though normally concealed by hair and smoke-grey pollen ; seventh tergite entirely grey ; lateral extremities and hind borders of all tergites clothed with glistening hair, longer and ochreous on lateral extremities of second and two or three following segments, shorter and paler elsewhere ; black area on second tergite clothed with yellowish hair, corresponding areas on two following tergites clothed with short, erect black hair ; venter smoke-grey, clothed with appressed, glistening, cream-coloured hair ; second sternite with a transversely elongate, somewhat reniform, fuscous black blotch in middle line, resting on or close to anterior border and confined to anterior half of segment, third and three following sternites each with a sooty black, transverse band on front border, widely separated in each case from lateral margins, and from twice to four times deeper on third than on either of the other sternites, these bands clothed with short, erect, black hair. *Wings* with auxiliary and first longitudinal veins, second longitudinal from base to a little beyond origin of third longitudinal, praefurcal portion of fourth longitudinal, and extreme bases of fifth and sixth longitudinal veins ochreous ; veins otherwise more or less dark brown. *Squamae* cream-buff. *Halteres* maize-yellow, knobs sometimes darker (mummy-brown) at base. *Legs* : coxae and femora deep mouse-grey, clothed with yellowish hair ; tibiae and tarsi clove-brown, clothed with minute black hairs, tarsal joints sometimes paler towards base.

South Africa (Cape Province) ; type and para-type from Bizana, East Pondoland, 1912(—*Goodall* : presented by Mr. T. B. Goodall).

The species described above shows a decided resemblance to *Buplex* (*Pangonia*) *suavis*, Lw., but, apart from its smaller size, is distinguishable, *inter alia*, by the presence of the two blackish stripes on the front ; by the outer two of the three longitudinal smoke-grey stripes on the disk of the scutum being narrower ; by the absence of a brown blotch near the tip of the wing, above the fork of the third longitudinal vein ; and by the veins in the region of the discal cell being suffused with mummy-brown.

Genus **Corizoneura**, Rond.

Corizoneura formosa, sp. n.

♂.—Length (4 specimens) 20 to 21·4, mm. ; width of head 6 to 6·4 mm. ; distance from upper margin of occiput to anterior extremity of face 5 to 5·25 mm. ; length of proboscis 13 to 15 mm. ; length of wing 17·4 to 18 mm. ; wing-expanse 21·5 to 23 mm.

Dorsum of thorax dark olivaceous black, with broad smoke-grey lateral borders clothed with cream-coloured hair, and with two narrow, smoke-grey, admedian, longitudinal stripes ; dorsum of abdomen ochraceous tawny, with distal extremity (fifth to seventh segments) infuscated (iron-grey to olivaceous black), a large black median blotch on each of the first four visible segments, and fourth segment bordered posteriorly with appressed, silvery white and ochreous hair ; venter cinnamon-buff or cinnamon-coloured, with last three segments sometimes mouse-grey and lateral extremities of first visible scute neutral grey ; wings with a sepiaceous tinge ; processess at tips of first and second joints of front tarsus in ♂ very long.

Head : face bluntly conical, moderately produced ; front and face (except sides of facial prominence below, which are clove-brown and shining) pinkish buff pollinose, front and borders of face adjacent to eyes clothed with longish, cream-buff hair : occiput smoke-grey, clothed above with cream-buff, below with whitish hair ; jowls and basi-occipital region pale smoke-grey, clothed with long whitish hair ; *palpi* russet, dark brown on outer side, proximal joint with a bunch of whitish hair at base below ; first and second joints of *antennae* isabella-coloured pollinose, clothed above and below with longish hair, generally black or blackish but sometimes mainly cream-coloured on first joint, third joint ferruginous or vinaceous rufous, clove-brown at tip. *Thorax* : dorsum, including scutellum, clothed for most part with somewhat appressed, cream or cream-buff-coloured hair, often but little visible when regarded from above, hair above lateral borders between bases of wings often largely or mainly dark brown, pleurae and pectus clothed with fairly long, whitish or yellowish white hair. *Abdomen* : except on first (visible) tergite, on which median blotch extends to or is but narrowly separated from hind margin, black median blotches, which rest on front margin, do not reach hind border ; posterior angles of first and second tergites clothed with yellowish or whitish hair, hind border of second tergite with a patch of glistening, appressed, ivory-yellow or cream-buff-coloured hair in middle line, light-haired hind border of fourth tergite expanded in middle line and at each extremity, lateral extremities of sixth and seventh tergites generally clothed with glistening silvery white hair, lateral extremities of second to fourth tergites inclusive, except as already stated, clothed with black hair, ochraceous tawny area of first and second tergites clothed mainly with minute, glistening, appressed, ochreous hairs, corresponding area on third and fourth tergites clothed with minute black or blackish hairs, fifth and sixth tergites (except lateral extremities in case of latter) clothed with black hair ; venter clothed with minute, appressed, glistening, cream-buff-coloured hairs, fifth sternite sometimes largely clothed with minute, black or blackish hairs. *Wings* : veins sepia-coloured, adjacent membrane suffused with same colour at base, and to a less extent at level of proximal extremity of discal cell. *Squamae* waxen ochraceous buff or pale orange-yellow, fringed with minute yellowish hairs.

Halteres light chestnut-brown, tips of knobs light buff or light ochraceous buff. *Legs* : coxae neutral grey, clothed with whitish hair, which is longer on front pair ;

femora russet (extreme tips ochraceous buff), clothed mainly with whitish or yellowish white hair, antero-inferior area of front pair with minute, erect, blackish hairs ; front and middle tibiae ochraceous buff, clothed with minute, glistening, yellowish or ochreous hairs, hind tibiae and hind tarsi russet-brown, clothed with black hair, distal extremities of hind tarsal joints blackish ; front tarsi ochraceous buff or ochraceous tawny, distal extremities of last three joints dark brown, body of second joint very short, tongue-like process at its distal extremity very long (longer than following joint), process at end of first joint overlapping and closely applied to first two-thirds of following joint ; first joint of middle tarsi cream-buff, remaining joints dark brown or mummy-brown, blackish brown at tips.

South Africa (Cape Province) : type and three para-types from Deelfontein, 7.xii.1902 (presented by *Colonel Sloggett, A.M.S.*—now *Lieut.-General Sir A. T. Sloggett, K.C.B., K.C.M.G.*).

This handsome species presents a decided resemblance to *Corizoneura aethiopica*, Thunb., another inhabitant of the South African portion of the Ethiopian Region, but can at once be distinguished, *inter alia*, by the presence of the conspicuous, smoke-grey, admedian, longitudinal stripes on the dorsum of the thorax.

Corizoneura schwetzi, sp. n.

♂ ♀.—Length, ♂ (6 specimens) 16·4 to 18 mm., ♀ (6 specimens) 16 to 18·6 mm. ; width of head, ♂ just over 5 to 5·4 mm., ♀ 5·2 to 5·75 mm. ; distance from upper margin of occiput to anterior extremity of face, ♂ 4·2 to 4·5 mm., ♀ 4·5 to 4·8 mm. ; width of front of ♀ at vertex 0·6 to 0·75 mm. ; length of proboscis, ♂ 15 to 15·25 mm., ♀ 11·75 to 13·75 mm. ; length of wing, ♂ 15 to 15·2 mm., ♀ 15·5 to 17·25 mm.

Dusky species, with base of abdomen paler ; dorsum of thorax dark brownish olive, with a broad, indistinct, blackish brown longitudinal stripe along each side above lateral margin, a narrow, elongate, pale spot (composed of Naples yellow or cream-buff hair) above base of each wing in front of postalar callus, and a short but conspicuous stripe of black hair between base of costa and humeral callus on each side ; dorsum of abdomen with first two (visible) segments cinnamon-buff or tawny olive in ♂, ochraceous tawny in ♀, ♂ with a blackish brown median triangular spot at base of second segment, tergites of third and following abdominal segments blackish brown or black, fourth segment posteriorly with a conspicuous transverse band of appressed, glistening, silvery white hair ; venter abruptly bicoloured, proximal portion as far as base of third (visible) sternite, ivory-yellow, cream or cream-buff-coloured, remainder blackish brown ; wings strongly and uniformly tinged with sepia.

Head drab pollinose, posterior orbits paler (light greyish olive above, smoke-grey or pale smoke-grey below), shining callus on each side of face below antenna black, sharply defined, sides of face below calli more or less dark brown or blackish brown owing to ground-colour showing through pollinose covering, lower border of sides of face in ♂ shining blackish brown, deeper posteriorly, distal extremity of face in ♀ shining blackish brown, sparsely clothed with drab pollen, in both sexes a more or less distinct, somewhat triangular, olive-buff or pale olive-buff, pollinose spot on each side of lower part of front, between base of antenna, margin of eye and shining callus ; front in ♀ with following series of dark brown marks—

a transversely oblong spot occupying ocellar region of vertex but not extending to eyes, a pair of somewhat guttate spots in centre of front, indistinctly connected with foregoing spot but likewise not in contact with eyes, and an oblique spot on each side below, extending from base of antenna to eye, above the light (olive buff or pale olive buff) spot already mentioned; front in ♂ clothed with black hair, in ♀ with shorter blackish hair, mingled with paler hair in upper portion, posterior orbits in both sexes fringed above with yellowish hair and below with longer whitish hair, basi-occipital region and jowls densely clothed with fairly long, whitish hair, lower borders of sides of face clothed posteriorly with black or blackish hair, more conspicuous in ♂ than in ♀; *palpi* russet-brown in ♂, russet in ♀, terminal segment (elongate and very narrow in ♂) clothed with minute black or blackish hairs, proximal segment, especially in ♀, clothed below with longer hair, brownish or blackish brown anteriorly, yellowish or whitish posteriorly; *antennae* russet, first and second joints more or less smoke-grey pollinose, clothed with black hair. *Thorax*: dorsum clothed anteriorly with silky, tawny olive or ochreous hair, posteriorly, including base of scutellum, with fine, erect, black hair, postalar calli, and scutellum, except as stated, clothed with Naples yellow or cream buff hair, hairy covering of central portion of dorsum visible only when viewed from side; pleurae and pectus clothed with longish hair, for most part cream buff (whitish on propleurae) in colour, a tuft of black hair (less conspicuous in ♀, in which sex it is often much reduced) below base of wing on each side; sternopleurae in ♂ sometimes clothed mainly with black or blackish hair. *Abdomen*: hind border (distal third or rather less) of second (visible) tergite clothed with minute, appressed hairs, which are silvery white or whitish at and towards lateral extremities of segment, and sparser and more yellowish (often glistening cream-buff) in vicinity of median line (owing to paler ground colour, whitish transverse band thus formed is, except at lateral extremities, less conspicuous than corresponding band on fourth segment); base of first (visible) tergite with a blackish brown, median area, extending beyond scutellum, but not or barely reaching hind margin except in middle line in ♂, in which sex it is more or less distinctly connected with triangular spot on second segment; blackish brown median triangle on second tergite in ♂ with its base resting on or close to anterior margin, and its apex reaching or extending somewhat beyond middle of segment; third tergite sometimes irregularly paler (cinnamon brown) at base and on hind border; hairs in silvery white transverse band on fourth tergite somewhat yellowish in vicinity of middle line; seventh tergite in ♀, as well as frequently hind borders of fifth and sixth tergites, often dull fuscous; lateral extremities, or at least posterior angles, of fifth and sixth tergites each clothed with a prominent tuft of silvery white hair; posterior angles, as well as in ♀ hind margin of first (visible) tergite clothed with shining ochreous or pale ochraceous orange hair; dorsum of abdomen except as already stated clothed with minute, appressed, black hairs; first (visible) sternite bare, second sternite clothed with minute, appressed, glistening cream-coloured hairs (anterior border of second sternite fringed with fine, erect, black or blackish hair, shorter and less developed in ♀ than in ♂, in which sex fine, recumbent, black hairs are also present among the cream-coloured hair, especially towards lateral extremities of the scute), blackish brown portion of venter clothed with black hair, among which a few pale hairs are occasionally present

on one or more of fourth and following segments. *Wings*: appendix to anterior branch of third longitudinal vein, though of variable length, as a rule relatively somewhat long. *Squamae* isabella-coloured. *Halteres* mummy-brown, knobs in ♀ often paler (cream-buff) at tip. *Legs*: front coxae neutral grey, clothed with cream-coloured or cream-buff hair, middle and hind coxae deep neutral grey or dark neutral grey, clothed with black hair, hind coxae in ♀ also with some yellowish hairs; hind femora in ♂ and bases of front and middle femora in same sex blackish brown, front and middle femora in ♂ except at base russet-brown or cinnamon-brown, all femora in ♂ clothed with black hair, femora in ♀ paler, and clothed largely with ochraceous buff or ochreous hair as well as with black hair; coloration of tibiae and tarsi and of their hairy covering alike in both sexes, front and middle tibiae ochraceous buff or ochraceous tawny, clothed with minute, appressed glistening ochraceous buff hair, hind tibiae and hind tarsi blackish brown, clothed with black hair, tips of second and two following tarsal joints clothed below with ferruginous hair, similarly coloured hair also largely present, at least in ♀, on under side of first tarsal joint, front and middle tarsi ochraceous tawny, clothed above with black hair, last joint in each case, as well as distal extremities of preceding joints mummy-brown, processes at tips of first and second joints of front tarsi in ♂ of moderate size, in neither case reaching distal extremity of following joint.

Belgian Congo (North Katanga) and Tanganyika Territory. Typical series from Kakanu (between 15 and 16 miles south of Kisengwa, R. Lomami), N. Katanga, vi. 1918 (*Dr. J. Schwetz*). Type of ♂, type of ♀, 36 ♂ and 2 ♀ para-types, in Musée Royal d'Histoire Naturelle de Belgique (Brussels); 6 ♂ and 6 ♀ para-types, in British Museum (Natural History)—presented by M. G. Severin; 1 ♀, from Tanganyika Territory (formerly German East Africa), 30° 55′ E. Long., 2° 5′ S. Lat., 16. vi. 1916 (*Dr. G. D. H. Carpenter*), in British Museum (Natural History), presented by Imperial Bureau of Entomology.

This fine species, with which the author has much pleasure in connecting the name of its discoverer (the well-known student of tsetse-fly bionomics in North Katanga), was met with by the investigator in question in large numbers in the vicinity of Kakanu.* On 6th June 1918, in a belt of forest several hundred metres in breadth and about 3¾ miles from Kakanu, Dr. Schwetz's native carriers succeeded in catching some 2,000 specimens of *C. schwetzi*, from 80 to 90 per cent. of which were males.† Unlike *Corizoneura inornata*, Austen (see below), which is found in the open, *C. schwetzi* does not occur outside the forest. According to Dr. Schwetz,‡ in the case of the present and the following species (*C. inornata*, Austen) at least, the labium itself is the piercing organ, and in the act of biting is thrust by the insect deeply into the skin of its victim. It is therefore interesting and possibly suggestive to note that, in the ♀ taken by Dr. Carpenter in Tanganyika Territory, the labium

* *Cf.* Schwetz, "Dix Jours d'Observations sur les Moeurs de la 'Pangonia zonata' et de la 'Pangonia oldii' (Deuxième Note)": *Revue Zoologique Africaine*, vii, pp. 92–106 (1919).—*Cf.* also the earlier paper by the same author, "Quelques Observations Préliminaires sur les Moeurs de la 'Pangonia zonata'": *ibid.*, pp. 46–54. In both of the memoirs cited *Corizoneura schwetzi* is referred to as *Pangonia oldii*, while the species termed *Pangonia zonata* is really *Corizoneura inornata*, Austen.

† *Cf.* Schwetz, *loc. cit.*, p. 103.

‡ See below, p. 147.

only projects 7·5 mm. beyond the extremity of the clypeus, exceeding the length of the labrum-epipharynx and the other mouth-parts by little more than the labella, while the proximal portion of the labium is bent backwards underneath the head, and beneath the cleft between head and thorax forms an angle of 45° with the distal portion.

Although superficially presenting a decided resemblance to *Pangonia oldii*, Austen, *Corizoneura schwetzi* can be distinguished from that species *inter alia* by the processes (entirely wanting in *P. oldii*) at the tips of the first and second joints of the front tarsi in the ♂; by the much greater development of the dark spot (often scarcely more than vestigial in *P. oldii*) at the base of the second abdominal tergite in the same sex; and in both sexes by the short stripe of black hair on each side of the dorsum of the thorax, in front of the base of the wing.

From *Corizoneura inornata*, Austen, apart from obvious differences in coloration, especially the sharply bicoloured venter of the species just described, *C. schwetzi* is distinguished by the inferior development of the processes at the tips of the first and second joints of the front tarsi in the ♂. Whereas in *C. inornata* ♂ each of these processes is so long as to project beyond the tip (excluding the process in the case of the second segment) of the following joint, in *C. schwetzi* ♂ neither process reaches the tip of the succeeding joint.

Corizoneura inornata, Austen.

Diatomineura inornata, Austen, Bull. Ent. Res. i, p. 282 (1911).

This species was described from a single ♀, obtained in September 1907, in S. Katanga, Belgian Congo, between Bunkeya and Kambove, at an altitude of 3,500 ft., by *Dr. Sheffield Neave*. The kindness of Dr. J. Schwetz, in presenting to the British Museum (Natural History) a large number of specimens of both sexes, now renders it possible to indicate the distinctive characters of the ♂.

C. inornata, Austen, ♂.—Apart from ordinary secondary sexual characters, agreeing generally with the ♀ except as follows. *Head*: hair clothing jowls and basi-occipital region often hoary or nearly white; first two joints of *antennae* clothed mainly with black hair. *Thorax*: pleurae on each side with a tuft of black hair below base of wing. *Abdomen*: first (visible) tergite with a median brownish black area at base, projecting somewhat beyond scutellum, but not reaching hind margin; second tergite with a conspicuous, median, brownish black, triangular spot resting on front margin, and varying in size in different individuals, but not extending beyond middle of segment, if so far; fifth and sixth tergites mainly brownish black, blackish brown or clove-brown, each of the two preceding tergites often with an ill-defined median blotch of same colour occupying anterior two-thirds. *Legs*: front and middle femora clothed largely with black hair, at least towards base, hind legs clothed mainly with black hair, processes at tips of first and second joints of front tarsi very long, in each case projecting beyond end of following joint (excluding process in case of second segment).

In the papers already referred to,* under the name "*Pangonia zonata*," Dr. Schwetz has furnished a series of interesting field notes on the behaviour of this

* P. 145, note.*

species, which, at the end of May 1914 and at the close of the same month and beginning of June 1918, was found by him in great abundance in the vicinity of Kakanu, N. Katanga, at and about the flowers of *Acanthus montanus* (termed by the natives "Nafimbia"), which grows in sheets in open spaces outside the forest. According to Dr. Schwetz, the existence of *C. inornata* is "intimately connected" with that of the flowers in question, the nectar of which is imbibed by both sexes, though the females also suck blood on occasion. It is interesting to note that, having in a number of cases observed the process of sucking blood by females of this and the foregoing species (*Corizoneura schwetzi*, Austen), Dr. Schwetz states that, in these PANGONIINAE at any rate, the actual piercing organ is the *proboscis* (labium) itself, which is "evidently sufficiently rigid" to penetrate the human integument, and is driven by the insect "fairly and squarely into the skin to the extent of one-third or one-half of its length. . . ." *

Genus **Pangonia,** Latr.

Pangonja discors, sp. n.

♀.—Length (1 specimen) 19·6 mm.; width of head 5·6 mm.; width of front at vertex 0·75 mm.; distance from upper margin of occiput to anterior extremity of face 4·5 mm.; length of proboscis 5·5 mm.; length of wing 17·6 mm.

Deep black, somewhat shining; first (visible) and second abdominal tergites densely covered with pale gull-grey pollen, and thickly clothed with closely appressed, silvery white hair; area beneath scutellum free from pollen and clothed with black hairs, some black hairs also present in middle line on anterior border of second tergite, latter likewise exhibiting a broad, median, triangular area (its base resting on front margin, its apex directed backwards and reaching beyond middle of segment) which, like front border of same segment, has a blackish look owing to pollen on it being thinner than elsewhere; lateral extremities of second tergite clothed with black hair; wings mummy-brown, proximal half (as far as base of discal cell) and stigma pale orange-yellow or light orange-yellow.

Head: ocelli wanting; face moderately prominent, front above relatively somewhat narrow; area from middle of front to anterior margin of clypeus olive-buff, upper half of front fuscous black, sides of face clove-brown, occiput and basi-occipital region smoke-grey or pale smoke-grey, jowls clothed with yellowish cream-coloured hair; *palpi* clove-brown, terminal joint elongate, tapering to a point and somewhat curved; first and second joints of *antennae* dark mummy-brown, clothed with minute black hairs mixed with some minute yellowish hairs, first joint short, expanded portion of terminal joint cinnamon-brown (terminal portion missing in case of type). *Thorax*: postalar calli chestnut-brown; dorsum including scutellum clothed with short black hair, which on front border of scutellum is interspersed with minute, glistening, appressed, golden hairs, a few golden hairs also on upper portion of swelling occupying depression at each end of transverse suture, hair on pleurae and pectus entirely black or fuscous black. *Abdomen*: third (visible) and following tergites clothed with appressed, black hair; venter, except second sternite, clothed with appressed, black or brownish black hair, ventral surface of second segment

* *Cf.* Schwetz, Rev. Zool. Africaine, vii, pp. 101–102 (1919).

clothed with minute, appressed, glistening, yellowish white hairs, fore border and lateral extremities clothed with black hairs. *Wings*: transition from orange-yellow proximal to mummy-brown distal portion sharply marked, at least in case of type. *Squamae* ivory-yellow. *Halteres* ochraceous buff, stalks and knobs towards base brownish. *Legs*: coxae and femora dark brown or blackish brown, clothed with black hair, which on under side of hind femora is mixed with a certain number of minute, glistening tawny hairs, and on anterior surface of front coxae with a few golden hairs; tibiae and tarsi russet, clothed for most part with minute, appressed, glistening, ochraceous tawny hairs, last three joints of tarsi dark brown above.

Angola (*J. J. Monteiro*).

Pangonia discors resembles and is closely allied to the East African *P. beckeri*, Bezzi, but is readily distinguishable owing to, *inter alia*, its more prominent face and narrower upper part of the front, the entire absence of white hair on pleurae, postalar calli and front coxae, and the distal portion of the abdomen being entirely black and covered with black hair, instead of having the tip ochraceous tawny and clothed with glistening ochraceous orange or ochreous hair.

Pangonia lautissima, sp. n.

♂♀.—Length, ♂ (9 specimens) 17 to 19 mm., ♀ (3 specimens) 16 to 17·4 mm.; width of head, ♂ just under 5 to 5·4 mm., ♀ 5 to 5·6 mm.; width of front of ♀ at vertex just under 1 to 1·2 mm.; length of proboscis, ♂ just under 4 to 4·25 mm., ♀ 3·4 to 4·2 mm.; length of wing, ♂ 14 to 15·2 mm., ♀ 14 to 15·6 mm.

Shining black; basi-occipital region clothed and lower halves of posterior orbits fringed with orange-buff hair, and patches of similarly coloured hair on pleurae; wings with base and a deep anterior border extending to end of third costal cell ochraceous orange, and remainder of surface uniformly brownish black, with a strong purplish metallic sheen.

Head black, frontal triangle in ♂ and region of subcallus (area immediately above bases of antennae) in ♀ shimmering silvery white pollinose, a similar pollinose patch (clothed with a few whitish hairs, and usually more distinct and sharply defined in ♀ than in ♂) on each side of upper part of face in both sexes; face in both sexes tumid below antennal prominence, then indented or somewhat receding, not produced into a nose-like prolongation, front in ♀ deeply furrowed; occiput pallid neutral grey pollinose, clothed with whitish hair, posterior orbits silvery white, their upper halves fringed behind with minute blackish hairs; *palpi* and *antennae* black, proximal joints of both sparsely clothed with short, black or blackish hairs, third joint of antennae from certain aspects appearing dark olive-grey, mouse-grey or brownish grey pollinose. *Thorax*: dorsum including scutellum clothed with short black hair, humeral calli inconspicuously neutral grey pollinose and clothed on sides in front with pale orange-buff hair, postalar calli fringed posteriorly below with orange-buff hair; pleurae on each side with a thick tuft of orange-buff hair below humeral callus, and more posteriorly with two further tufts of similar hair arranged somewhat in the shape of a wide V, of which the anterior branch fringes the hind margin of the mesopleura, while the posterior runs back to the squamae; pleurae except as stated, and pectus except in front of front coxae clothed with black hair, pectus in front of front coxae neutral grey pollinose, clothed with pale orange-buff

hair. *Abdomen*: first six (visible) tergites in both sexes each with its lateral fourth on each side (rather more in case of ♀) clothed with close-set, appressed, minute, glistening smoke grey hairs (extreme lateral extremities of seventh tergite in ♀ clothed with hairs of same kind), so that dorsum of abdomen exhibits on each side a broad grey stripe, which in certain aspects contrasts fairly sharply with remainder of surface, which is clothed with minute appressed black hairs and thus forms a broad, longitudinal, median, black stripe; first (visible) tergite clothed with greyish pollen on each side at base, second tergite in both sexes on each side with a roughly semicircular whitish pollinose spot on hind margin, from most points of view concealed by the smoke-grey hair, but clearly visible when abdomen is looked at obliquely from behind, in ♀ a pair of similar but smaller whitish pollinose spots on hind margin of each of the two following tergites also; venter clothed with minute, appressed, glistening, smoke-grey hair, last two sternites, and sometimes median area of hind border of preceding sternite also, clothed mainly or entirely with black hair. *Wings*: extreme base of costa and first longitudinal vein brownish black; ochraceous orange base extending into bases of basal and anal cells, similarly coloured anterior border including upper margin of first basal and proximal fourth of first submarginal cell, thence tapering obliquely to end of third costal cell; veins within ochraceous orange area similarly coloured, elsewhere dark brown. *Squamae* light orange yellow. *Halteres*: stalks and knobs mummy-brown above and below, tips of knobs cream-buff. *Legs* black and clothed with black hair, front coxae anteriorly dark neutral grey pollinose, thinly clothed towards base with longish pale orange-buff hair.

Tanganyika Territory (formerly German East Africa): Itigi, iv, 1917 (*Dr. G. D. H. Carpenter*). Type of ♂, type of ♀, and 2 ♀ para-types, taken 18.iv.1917; 7 ♂ para-types, taken 15.iv.1917, "on composite flower"; 1 ♂ para-type, taken 6.iv.1917, "among low herbage." All foregoing presented by Imperial Bureau of Entomology, which retains possession of six additional para-types, taken by Dr. Carpenter at same time and place as specimens already enumerated.

The extremely striking and unusual-looking Tabanid just described belongs to the group of the genus *Pangonia* that includes *P. elongata*, Ric., *P. beckeri*, Bezzi, and *P. discors*, Austen, but is readily distinguishable from all three species by, apart from its sharply defined wing-markings and other characters, its unbanded abdomen and the patches of orange-buff hair on the pleurae. The coloration of the wings, in conjunction with the shining black body, would seem to suggest that *P. lautissima* possibly mimics some species of wasp (perhaps *Rhynchium cyanopterum*, Sauss.), and it is worthy of note that the same colours, though differing widely in extent and arrangement in the case of the wings, are exhibited by "*Pangonia*" *mesembrinoides*, Surc., of which the type was also obtained in Tanganyika Territory (Amani). The latter species, however, was incorrectly assigned by its describer to the genus *Pangonia*, and really belongs to a new genus allied to *Thriambeutes*, Grünb.

Pangonia carpenteri, sp. n.

♀.—Length (8 specimens) 15 to 16·6 mm.; width of head 4·25 to just under 5 mm.; width of front at vertex 0·6 mm.; distance from upper margin of occiput to anterior extremity of face 3·5 to 4 mm.; length of proboscis 11·75 to 13·75 mm.; length of wing 13·5 to 15 mm.

In ♀ sex, at any rate, a somewhat sombre-coloured species looking more like a small or medium-sized Corizoneura *than a* Pangonia, *and not unlike a smaller and more dusky form of* Corizoneura hastata, *Austen, of Portuguese E. Africa.—Face moderately produced ; dorsum of thorax olivaceous black, with a pair of broad, paler (greyish olive), narrowly separated or sometimes confluent, admedian, longitudinal stripes ; dorsum of abdomen shining blackish brown, on each side of base rather more than lateral third of first (visible) tergite ochraceous tawny, a similar area on each side of second tergite, or of second and third tergites, usually russet or chestnut-brown, lateral borders, posterior angles, and (at least in part) hind borders of second and fourth tergites clothed with glistening silvery white hair ; wings strongly tinged with sepia ; legs for most part ochraceous tawny.*

Head : ocelli wanting ; face and front clothed with yellowish grey or isabella-coloured pollen, and front thinly covered with yellowish hair, lower half of front, above antennal prominence, with an ill-defined, shining black, median longitudinal mark, upper half of front usually streaked with mummy-brown or dark brown along each side, while a narrow mummy-brown streak, which starts from base of antenna on each side, runs obliquely upwards and outwards, and joins corresponding eye just above base of antennal prominence ; below antennae, a shining black transverse band unites and includes the shining black facial calli ; jowls and basi-occipital region clothed with long, whitish hair ; occiput greyish olive or smoke-grey pollinose, sparsely clothed with cream-coloured hair, which also forms a short fringe behind posterior orbits above, lower portion of posterior orbits fringed with whitish hair ; *palpi* elongate, proximal joint russet-brown or deep mouse-grey, sparsely clothed with whitish hair on outer side and below, terminal joint russet, somewhat expanded in middle, clothed with minute black hairs ; first and second joints of *antennae* pinkish cinnamon or cinnamon-buff pollinose, both sometimes clothed with black hair though in some specimens hair on first joint is for most part yellowish, second joint usually with outstanding black hair above and below, third joint orange-cinnamon. *Thorax* : admedian stripes on dorsum entire, extending from front margin to prescutellar groove, outer border of each stripe paler in front of transverse suture ; dorsum including scutellum thickly clothed with fine yellowish hair, with which in some specimens on central part of posterior portion of scutum a few fine black or blackish hairs are intermixed ; postalar calli and lateral margins of dorsum behind transverse suture fringed with whitish hair, pleurae and pectus thickly clothed with similar hair. *Abdomen* : central portion of base of first (visible) tergite olivaceous black, basal angles of same tergite more or less distinctly neutral grey or dark neutral grey ; rather less than median third of second tergite and a broad median triangle on each of following tergites, in each case with its base resting on hind margin and its apex in contact with front margin, and on fourth and following tergites with its base expanded laterally so as to include entire hind border of segment, dull dark olive-grey ; olive-grey median area on second tergite (sometimes that on third tergite also) indented on each side ; second tergite at base with a median, semicircular, dead black spot, or in some cases with a pair of smaller spots, narrowly separated in middle line by a dark olive-grey longitudinal stripe ; first (visible) tergite with a median patch of glistening yellowish or pale yellowish hair, and clothed elsewhere with ochraceous hair ; second tergite, except on black spot

(or spots) on which hair is usually black or ochreous, clothed with minute, appressed, glistening silvery white hairs, which however, at least on each side of median olive-grey area, are often largely replaced by similar ochreous hairs; lateral borders of fourth and following tergites, as well as (at least in part) hind border of fourth tergite, clothed with glistening, silvery white hair, similar hair also usually visible on lateral margins of third tergite, towards posterior angles; dorsum except as stated clothed with appressed black hair; venter isabella-coloured or light brownish olive, clothed with minute, appressed, whitish or yellowish white hairs. *Wings*: veins mummy-brown; first posterior cell variable as usual as regards distance from hind margin at which it is closed, sometimes closed on margin itself, or even in one or other wing narrowly open. *Squamae* cream-buff. *Halteres*: knobs fuscous, stalks cinnamon-buff. *Legs*: coxae neutral grey, clothed with whitish hair, anterior and inferior surfaces of femora clothed, at least in part, with black hair, femora elsewhere clothed with yellowish hair, tibiae and tarsi clothed with minute, appressed, ochreous hairs, extensor surfaces of hind tibiae and hind tarsi clothed, at least in part, with black hair; front femora blackish brown at base and sometimes also on greater part of under side, joints of front tarsi often mummy-brown or dark brown at tips above, those of hind tarsi similarly marked, or sometimes entire upper surface of hind tarsi, except base of first joint, dark brown.

Tanganyika Territory: Itigi, iv, 1917 (*Dr. G. D. H. Carpenter*). Type and 3 para-types, taken 18.iv.1917; 1 para-type, taken 15, iv, 1917, "on low herbage"; 1 para-type, taken 6.iv.1917, "hovering while feeding from composite flower; looking much like a *Bombylius*." All foregoing presented by Imperial Bureau of Entomology, in whose possession are two other para-types, taken by Dr. Carpenter at same time and place as specimens already mentioned.

So far as it is possible to judge from the ♀ alone, this species, which is named in honour of its discoverer and does not resemble any African *Pangonia* hitherto described, presents, apart from the venation, all the characteristics of a *Corizoneura*, to which genus it would have been assigned were it not that its posterior cell seems normally to be closed before reaching the wing-margin. Should the ♂ prove to have processes at the tips of the first and second joints of the front tarsi, *Pangonia carpenteri*, despite the transitional character of its venation, would more fittingly be placed under *Corizoneura*, so long as the independence of the latter be maintained.

Genus **Thriambeutes**, Grünb.

Thriambeutes fuscus, sp. n.

♂.—Length (1 specimen) 11·14 mm.; width of head 4·25 mm.; length of wing 10·5 mm.

Dorsum of thorax sepia-coloured, with traces of a faintly marked, paler, longitudinal median stripe in front of transverse suture, pleurae and pectus mummy-brown; abdomen uniformly blackish brown; wings mummy-brown, with a clear oblique transverse streak, commencing on anterior transverse vein (its base extending from commencement of lower border of distal fourth of first basal cell to proximal extremity of first posterior cell), including rather more than proximal third of discal cell, proximal extremity of fourth posterior cell, distal extremity of second basal cell, and upper border of proximal two-thirds of fifth posterior cell, but not reaching hind margin; legs blackish brown or black, middle tarsi cream-buff, last joint and tips of preceding joints cinnamon-brown.

Head black or blackish brown, occiput dark neutral grey pollinose, basi-occipital region thinly clothed with fine blackish brown hair ; ocelli present, enlarged facets of eyes very coarse, area occupied thereby same as in ♂ of genotype (*Thriambeutes singularis*, Grünb., of Togoland and S. Nigeria), *i.e.*, small facets confined to a deep lower border and a narrower hind border of uniform width running up to ocelli ; *palpi* blackish brown and clothed with fine hair of same colour, terminal joint elongate and curved but not conspicuously swollen, considerably smaller and narrower than in ♂ of genotype ; antennal protuberance large and prominent, considerably larger and more prominent than in ♂ of genotype ; first joint of *antennae* blackish brown, short, swollen, cylindrical, and clothed like second joint with blackish brown hair, second and third joints sepia-coloured, expanded portion of third joint rather broad. *Thorax* and *abdomen* thinly clothed with fine blackish brown hair. *Wings* : anal angle and lower region of distal extremity short of actual tip paler than elsewhere with exception of clear, transverse streak, a close scrutiny, when wing is viewed against a light back-ground, revealing beyond clear streak an ill-defined transverse band, which appears somewhat darker than remainder of surface ; *stigma* well developed, elongate, cinnamon-brown when seen against a light background. *Squamae* blackish brown. *Halteres* : knobs ivory yellow, stalks sepia-coloured. *Legs* : coxae, femora and tibiae clothed with blackish brown or blackish hair, middle as well as front tibiae swollen (front and hind tarsi, and hind tibiae missing in case of type).

South Africa, Bechuanaland Protectorate : N'Gami Country, 1897 (*Sir Frederick Lugard, G.C.M.G., C.B., D.S.O.*).

The species characterised above is readily distinguishable by its wing-markings alone, apart from all other characters, from *Thriambeutes singularis*, Grünb. (the only other member of its genus as yet described), in which moreover the body as well as the head and its appendages are in the ♂ uniformly tawny.

So far as it is possible to judge from a photograph, which is all that is at present available for comparison, what appears to be another ♂ of *Thriambeutes fuscus* is in the possession of Mr. R. W. Jack, Government Entomologist, Southern Rhodesia, and was taken by him in November 1914, in Sebungwe District, Southern Rhodesia, on the jacket of a companion. In Mr. Jack's specimen, however, the clear streak in the wing reaches the hind margin, while the margin of the anal angle, and a further portion of the hind border embracing part of the distal extremity of the second submarginal cell and the distal extremities of the first three posterior cells are also hyaline.

APHIDIDAE OF PERSIA.

By F. V. Theobald.

Aphis buxtoni, sp. nov. (fig. 1).

Alate viviparous female.

Head and thorax dark ; abdomen pale, apparently pale green, with dark lateral spots. Antennae, cauda and cornicles dark. Legs with mid and hind femora dark, front pair paler ; apices of tibiae and the tarsi dark. Antennae shorter than body, rather thick ; basal segment larger and paler than second ; third much longer than fourth and about as long as the sixth, with 18–20 small round pale sensoria over its whole length ; fourth segment very slightly longer than fifth, with 5–8 sensoria ; fifth with 4–7 sensoria of unequal size, exclusive of the usual subapical one ; sixth with the rather thick basal area less than one-third the length of flagellum, in some however almost half its length ; all the segments from the third imbricated. Eyes

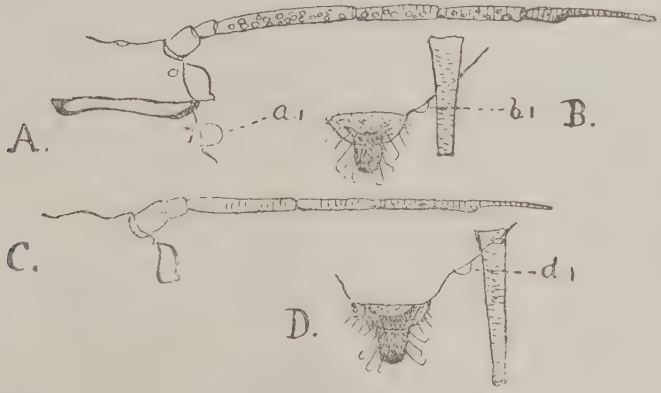

Fig. 1. *Aphis buxtoni*, sp. n.: A, B, alate ♀ ; a_1, lateral bladder-like papilla ; b_1, lateral papilla ; C, D, apterous ♀ ; d_1, lateral papilla.

large. Proboscis reaching to the third coxae. A large pale bladder-like papilla on each side of pronotum and five pairs of pale rounded papillae on sides of abdomen. Cornicles about as long and as thick as third antennal segment, cylindrical, markedly imbricated, not reaching to the level of the cauda. Cauda bluntly pointed, about half the length of the cornicles, spinose ; with numerous fine hairs, curved apically. Anal plate spinose, with fine pale hairs. Tibiae with numerous fine, pale, short hairs. Wings with normal venation ; veins and stigma brown, the veins very faintly and narrowly clouded on each side. *Length*, 2–2·2 mm.

Apterous viviparous female.

Pallid, with dark head, cornicles, cauda and anal plate, also dark antennae and mid and hind legs, the fore pair paler. Antennae shorter than body, rather thick ; basal segment larger than second, both very dark ; third paler at base, longer than fourth and about same length as sixth ; fourth a little longer than fifth, the latter with the usual sub-apical sensorium ; sixth with basal area nearly half the length of

flagellum ; segments 3–6 imbricated. Eyes dark, of moderate size. Proboscis reaching to the second coxae. Cornicles cylindrical, longer than third antennal segment, imbricated. Cauda blunt and rather short, not half the length of the cornicles, spinose, with numerous pale hairs ; broader than cornicles ; the hairs curved apically. Anal plate spinose, with long pale hairs. The rather thick set legs have the coxae and trochanters darker than the rest of the legs ; a few short hairs on the femora, many on the tibiae. *Length*, 2 to 2·5 mm.

Food-plant: Umbelliferae.

Persia : Enzeli, Caspian Coast, 6.vi.1919 (*P. A. Buxton*).

Types in the British Museum.

Described from a single perfect alate female and several apterae. One of the latter shows the cornicles not reaching the cauda, others passing it. It is a very marked species, the black cornicles, cauda, etc., showing up prominently against the pale body. The antennae are short, as in the genus *Cavariella* and the cauda is markedly spinose. I can see no trace in the mounted apterae of any lateral pronotal or abdominal papillae, as seen in the alate female. The larval stages are more uniform in colour, but in succeeding instars the blackness of the cornicles, etc., gradually becomes more pronounced.

This species was found in association with an ant that has been identified by Mr. W. C. Crawley as *Lasius emarginatus*, Latr., var. *nigro-emarginatus*, Forel.

Myzus mespiliella, sp. nov. (fig. 2).

Apterous viviparous female.

Green or yellowish green ; antennae of same colour as body, dusky at apex of fifth segment, the sixth dusky, with a more or less darkened area at the junction of basal portion and flagellum. Eyes deep reddish-black. Proboscis of same colour as body, dark at apex. Legs same colour as body, apex of tibiae and tarsi dusky. Cornicles and cauda of same colour as body ; in some the former seem a little darker. Anal plate darker than cauda.

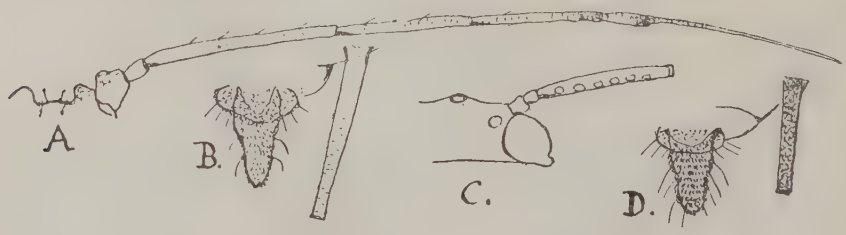

Fig. 2. *Myzus mespiliella*, sp. n. : A, B, apterous ♀ ; C, D, alate ♀.

Antennae longer than body ; basal segment larger than second ; third segment longer than fourth, but not quite so long as the sixth ; fourth a little longer than fifth ; the sixth about as long as 4 + 5, with moderately long flagellum ; a few short hairs on third and fourth. Proboscis rather long, reaching to or just beyond the third coxae. Cornicles slightly longer than fourth antennal segment, cylindrical, slightly broadening at the base, markedly imbricated. Cauda reaching not quite to the level of the cornicles, less than half their length, narrowly triangulate or pointed, spinose, with two pairs of lateral hairs. Anal plate spinose, with several long hairs. Tibiae with numerous small hairs, becoming longer near apex. The

vertex shows two short and two longer slightly capitate hairs. A few short blunt lateral abdominal processes. *Length*, 1·5–1·8 mm.

Alate viviparous female.

Only imperfect specimens sent. Apparently dark and of reddish hue with dark head, thorax, cornicles and cauda ; legs paler, with dark apices to tibiae and dark tarsi ; two basal segments of antennae dark, third pale. The abdomen has dark lateral and dorsal spots and the proboscis is pale towards the tip, but extreme apex dark. The basal segment of antennae larger than second ; the third with 6–7 large round sensoria in a line. Eyes large and deep reddish-black. The black cornicles are cylindrical, shorter, but a little thicker than third antennal segment, slightly expanding basally and not quite reaching the level of the cauda, markedly imbricated. Cauda black, more than half the length of the cornicles, more or less constricted near the middle, spinose, with long, fine hairs ; blunt apically. Anal plate black, with long pale hairs. Wings large, venation normal. The abdomen shows four small dark blunt lateral processes before the cornicles and one between the cornicles and cauda. *Length*, 1·8–2 mm.

Food-plant : Medlar (*Mespilus*).

N. W. Persia : Enzeli, 29.iv.1919 (*P. A. Buxton*).

Types in the British Museum.

Described from several perfect apterous females, but both alatae damaged, neither showing complete antennae. The sensoria on the third segment are marked. The only other *Mespilus* species is Van der Goot's *Myzus mespili*, which is very distinct. The vertex and lobes of the apterae and the basal segment of the antennae approach to some extent those of the genus *Phorodon*, but in the alate stage it is a distinct *Myzus*. It was found on the young twigs of the medlars, not doing much harm. Ants were found in attendance.

Aphis punicae, Passerini (fig. 3).

A. punicae, Pass., Aphid. Italicae, pp. 32 et 42, n. 26 (1863).

Alate viviparous female.

Antennae shorter than body ; two basal segments dark and a dark area at apex of fifth and around the sensoria on sixth, or all dark except base of third segment ;

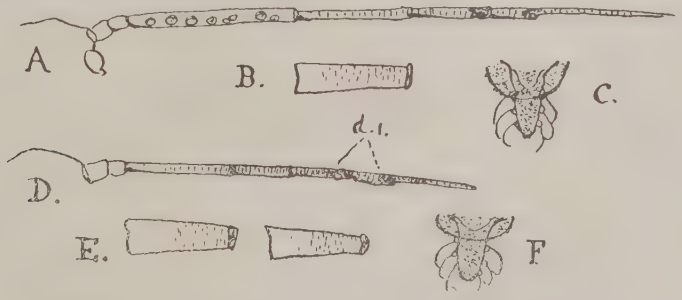

Fig. 3. *Aphis punicae*, Pass. : A, B, C, alate ♀ ; D, E, F, apterous ♀ ; d^2_1, dark areas on antennae.

basal segment wider but no longer than second ; third nearly as long as the sixth, with 6–8 sensoria spread over its whole length, two frequently smaller than the others ; fourth segment longer than fifth, the latter with the usual subapical sensorium ; the sixth about as long as 4 + 5 ; fourth to sixth imbricated. Cornicles

dark, about as long as fourth antennal segment and thicker, cylindrical, imbricated, not reaching to the tip of cauda. Cauda pale, shorter than the cornicles, with three pairs of lateral hairs, curved apically and arising from prominent tubercles. Anal plate darker than cauda. Femora of mid and hind legs dark, except just at base : front pair paler ; apices of tibiae and the tarsi dark. Wings normal. *Length*, 1–1·5 mm.

Apterous viviparous female.

Antennae shorter than body, pallid, except for a small dark area at apex of fifth segment and one around sensoria on sixth ; basal segment wider but scarcely longer than second ; third a little shorter than sixth, but longer than fourth ; fourth and fifth about equal ; sixth with flagellum about twice as long as basal area. Cornicles about as long as third antennal segment, broadening basally, pale, dark at apex, not reaching as far as cauda. Cauda pale, with three hairs on each side, curved at their tips and arising from marked tubercles ; not quite as long as cornicles. Anal plate dark. Marked pronotal lateral tubercles and one each side of body before the hind legs. Apices of tibiae and the tarsi dark. Proboscis not reaching to third coxae. *Length*, 1–1·5 mm.

Food-plant : Wild Pomegranate.

N.W. Persia : Tula Road, Talish District, S.W. Coast of Caspian, 9. vii. and 5. viii. 1919 (*P. A. Buxton*). Italy (*Passerini* and *Theobald*).

Apparently the apterae only were described by Passerini. The alatae seem to vary in the colour of the antennae in the mounted specimens, some are pale with two dark areas, others all dark except the base of the third segment. The specimens taken by Mr. Buxton were on the twigs, attended by ants (*Cremastogaster scutellaris schmidti*, Mayr, and *Tapinoma erraticum nigerrimum*, Nyl.). Passerini records it from *Punica granatum* and *P. sylvestris*. The *Aphis punicellae* I described from Egypt on *P. granatum* (Bull. Ent. Res. vi, p. 125) is quite a distinct species.

Lachnus pyri, Buckton (fig. 4).

L. pyri, Buckt., Indian Museum Notes, iv, p. 271, pl. xvi (1899).

Taken on pears at Karmanshah, W. Persia (4. xii. 18) by Mr. P. A. Buxton.

This species was described by Buckton (with notes by E. E. Green) from pears in Ceylon. The Persian specimens agree with the Pear Lachnid I have from Ceylon and answer generally to Buckton's short description. I append some characters of the antennae, etc.

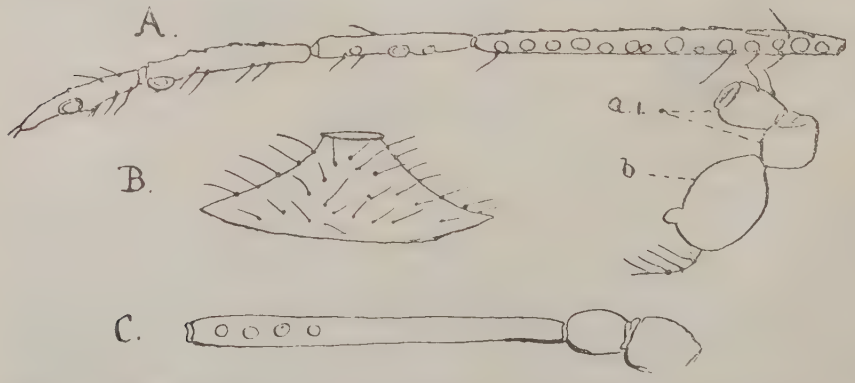

Fig. 4. *Lachnus pyri*, Buckt. : A, antenna of alate ♀ ; *a*, basal segments ; *b*, eye ; B, cornicle ; C, 1st to 3rd antennal segments of apterous ♀.

Alate viviparous female.

Antennae of six segments; first two large and dark, third the longest, with 13–15 round sensoria of unequal size and a few hairs; fourth about as long as fifth, with 3 sensoria; fifth longer than sixth, with one large subapical sensorium; sixth with 'nail' shorter than basal area and a large sensorium at its base, a few moderately long hairs. Eyes large. Cornicles dark, of normal form, hairy.

Apterous viviparous female.

Basal segments of antennae large and dark; third segment with 3–4 uniform round sensoria situated near apex. Cornicles as in alate ♀. A marked median abdominal tubercle.

The specimens sent by Mr. Buxton were all very much damaged. Another Lachnid (*Nippolachnus piri*, Matsumura) occurs on *Pirus sinensis* in Japan, but is very distinct (*vide*, "A list of the Aphididae of Japan, with descriptions of New Species," Journal of the College of Agriculture, Tohoku Imperial University, vii. pt. 6, p. 382, July 1917).

THE CAMPAIGN AGAINST *PHYTALUS SMITHI* IN THE COLONY OF MAURITIUS.

By H. A. Tempany, D.Sc.,
Director of Agriculture,

and D. d'Emmerez de Charmoy,
Entomologist.

(Plate V.)

The following paper contains an account of the campaign which has been in progress against *Phytalus smithi* during the past 8½ years. The history of the pest in Mauritius and the measures which have been adopted for its control are of interest both from an entomological and from an administrative point of view.

Published accounts of the pest are contained (1) in a monograph, prepared by one of us at the time of its first appearance in the Colony, and printed in Mauritius; (2) in a paper on the introduction of *Tiphia parallela* into Mauritius, from Barbados, for the purpose of the control of the insect, published in the Bulletin of Entomological Research (iii, pp. 93–102), also published subsequently as a Bulletin of the Department of Agriculture, in Mauritius; (3) in the annual administrative reports on the Department of Agriculture in Mauritius for the years 1913–1918; and (4) in special reports on the progress of the work of control which have been prepared from time to time for presentation to the Government and to the Board of Agriculture in Mauritius.

As, however, the information is scattered, and many of the reports and papers are difficult of access to the general reader, the following summarised account has been prepared for publication.

Historical.

The first record of the appearance of *Phytalus smithi* as a pest in Mauritius occurred in the month of July 1911, on lands of Mon Rocher Estate adjoining the Royal Botanical Gardens, Pamplemousses. Once the pest had been detected, it became apparent that damage on a very considerable scale was being occasioned thereby, many fields of both plant and ratoon canes being found to be almost totally destroyed by the grubs.

The insect was apparently imported into Mauritius, either from Barbados or South America, probably in earth containing rooted sugar-canes. The exact date of its introduction is uncertain, but it is probable that it must antedate its discovery as a pest in the Pamplemousses district by five or six years at least.

Its observation in Mauritius was followed by prompt and energetic measures for its control, which have been continued up to the present time. The effect of these

measures has been to circumscribe to a large extent the infested area, and to mitigate the damage caused thereby. Had these measures not been applied, it seems reasonably certain that the cane-growing industry, at any rate in the lower regions of the island, would have sustained much more serious damage than has actually been experienced.

At the time of the first outbreak, no properly constituted authority existed for dealing with administrative measures directed to the control of plant pests and diseases, and consequently two committees were appointed, charged with the supervision of the work of control, one being a consultative and the other an executive body. At the same time the present Entomologist of the Department of Agriculture, who then held the office of Curator of the Mauritius Institute and Museum, was appointed temporarily for executive work in connection with the operations, the work being attached, for administrative purposes, to the Department of Forests.

On the formation of the Department of Agriculture in 1913, the control of these and other operations against plant pests and diseases was transferred definitely to the control of this Department and has remained thereunder ever since.

The Habits of the Beetle and the Damage done by it.

The character of this Melolonthid beetle and the nature of the damage occasioned by it are now too well known to need any detailed description, and for a complete account of the various stages in its life-history reference may be made to the report on *Phytalus smithi* by one of us (D. d'Emmerez de Charmoy), previously referred to.

Only one generation is produced per annum. Though the period of the greatest emergence does not last more than 3 to 4 months, from November to January or February, these insects can be found in the adult stage all the year round in varying numbers, according to the season, the development being to some extent dependent upon climatic conditions. Soil temperature and soil moisture are factors influencing the duration of the pupal and larval stages, as well as the incubation of the eggs.

The following table brings out the difference existing between insects reared at Phoenix, at an altitude of 1,311 ft., and those reared at Pamplemousses, where the altitude is 208 ft., the temperature being in the latter district much higher than in the former.

		No. of days		Remarks
		Minimum	Maximum	
Egg stage		7	23	Maximum at Phoenix in September. Minimum at Pamplemousses in December
Larva:	active	210	240	
	inactive—prepupal	30	45	
Pupa		18	25	
Imago	prior to emergence from soil	10	15	
	first copulation after emergence	10	15	
	copulation	60	75	
	laying perod	30	120	
	after the laying period	30	90	
		405	648	

It would appear that climate is a most important factor in the control of the pest ; to exemplify this it may be stated that the insect was first detected in the year 1907 at Reduit at an elevation of 1,100 feet, where the climate is distinctly cooler than at Pamplemousses. The insect has been kept under close observation at this point for a number of years past and has not up to the present shown any signs of becoming a serious pest. In this connection mention may be made of the very recent discovery of the beetle on a small area at Joli Bois in the Savanne district of the island at an elevation of about 900 feet. At this particular point it seems probable that the insect was introduced from Pamplemousses in planting materials transported from forest nurseries formerly existing in Pamplemousses Gardens, for the purpose of restocking Government forests adjacent to this point. No planting material has been sent out from these nurseries since the discovery of the pest at Pamplemousses in 1911, but just prior to this, important consignments of such materials were delivered at Riviere du Poste Railway Station, which is in the centre of the infested zone and undoubtedly is the focus from which the infestation originated. The fact that during an interval of eight years the pest has extended only to an insignificant extent is further evidence of the effect of climate on its incidence.

The extent of the infested area in the Pamplemousses district now measures approximately twelve square miles. When the pest was first detected in 1911, the infested area measured only three square miles, the increase in the intervening period being due to outward spread. Energetic measures, described in a later section of this paper, are now being taken with a view to circumscribing its further extension. The Royal Botanical Gardens are approximately in the centre of the infested zone and are apparently the nucleus from which infestation originally started.

Remedial Measures.

The remedial measures that have been applied to combat the pest may be grouped under the following heads :—

(*a*) the collection and destruction of adult insects on emergence ;

(*b*) the digging out and destruction of larvae in badly infected fields ;

(*c*) census and survey work designed to ascertain the location and distribution of foci of infestation throughout the infested area ;

(*d*) the introduction and dissemination of the natural parasitic enemies of the pest ;

(*e*) legislative measures directed towards preventing the spread of the pest to uninfested regions, and affording the necessary powers to the authorities to carry out protective and destructive work in infested areas ;

(*f*) experimental work on other possible means of control.

The control work in the Pamplemousses area has assumed very considerable proportions, and the local headquarters for dealing with the work have for some years been established in the Royal Botanical Gardens. In the following paragraphs an account is given of the administrative and practical methods employed under each of the above sub-heads, after which information is supplied concerning the results of the work.

Collection of the Insects.

The collection of insects by hand has proved one of the most effective methods of controlling the pest, and in this connection organised work under Government supervision on a considerable scale has been carried out systematically each year.

The methods adopted have comprised the collection of insects by the general public, combined with collection by gangs in localities where the infestation is light. In regard to public collections the principle observed is the purchase of the collected beetles at rates dictated by the abundance of the insects at any particular period, as gauged by the number of insects captured ; a sliding scale of payments has been worked out in this connection, and the rates paid are fixed in accordance therewith. The work of collecting usually commences in the month of October and continues uninterruptedly till March. The months of greatest emergence are December and January, during which period the daily catches not infrequently run into several millions.

The capture of the beetles commences at about 6.30 p.m. and continues up to 10.30 p.m. The habit of the insect lends itself to this particular form of control measure, inasmuch as at nightfall it emerges from the soil, where it lies buried during the day, takes a short flight to the nearest bush or tree, and remains there for hours nibbling slowly at the leaf on which it has settled. The insects are undisturbed by lights and are readily collected by searchers who look for them with lanterns.

Beetles caught each night are received, measured and purchased at Pamplemoussses Gardens on the following morning, and immediately after measurement destroyed by fire. During busy seasons the work of measuring beetles occupies many hours. The method employed in computing the number of captured beetles is by means of measurement in containers of standard size and known capacity. To facilitate the work of collecting beetles, purchasers are licensed by the Agricultural Department, who buy beetles from the general public at certain specified points on the night they are collected and resell to the officer in charge the next morning ; while many estates also follow the same practice, in some cases paying slightly enhanced premiums in order to attract collectors, and also supplying oil for lanterns, collecting receptacles, &c.

With regard to collection of insects by gangs as opposed to public collection, this form of control has of necessity to be practised in regions where the infestation is light and beetles are not numerous, since under the system of purchase, beetle hunters are obviously attracted only to localities in which insects are plentiful, while the scale of operations renders impossible any discrimination in the matter of prices in relation to the localities in which captures are effected.

Two quite distinct cases occur in which collection by gangs is indicated ; the first is that of places well within the infested area at which the beetles are not numerous ; the second is in the case of the peripheral zone, where infestation is light and where slow outward spread to previously uninfested regions is taking place.

This outward spreading constitutes one of the most serious aspects of the situation. By 1917 the increase in the infested area had become so marked that special measures to restrict the spread became necessary. With this object in view the periphery of the infested zone was resurveyed in 1917 ; following this the periphery was divided between a series of patrols, and to each patrol a special collecting gang was assigned. Each gang consists of from 8–10 labourers under the charge of a headman ; it is provided with powerful acetylene lights to assist in the detection of

insects, and is required to patrol the section allotted to it on a depth of ½ a mile at least once in each night, and to collect insects found occurring on this area. The gangs are regularly inspected by a travelling inspector, when attendances are verified, captures of insects checked, and the general working of the gang examined. As the result of work on these lines during two seasons there appears reason to believe that the rate of outward spread is becoming considerably reduced.

The collection of beetles during busy seasons affords part time employment to large numbers of people, and at such times the actual number engaged may total several thousands. The largest number of beetles captured on any one night amounts to 4,600,000, which was recorded on 12th January 1919. Emergence of beetles usually takes place in flights, large numbers appearing simultaneously for a short period and then rapidly diminishing. It is usual for two or more flights to be recorded in one season, and on occasions when beetles are numerous it is remarkable, after nightfall, to observe the country-side dotted with the lanterns of collectors.

The transport of the beetles from the points of collection gave rise some time ago to fears concerning possibilities of reinfestation owing to their escape from unsuitable containers. A special form of container, intended to preclude the escape of captured insects deposited therein, has in consequence been devised and efforts made to induce all persons engaged in the work of beetle collection to provide themselves therewith.

Daily returns of captures of beetles and of larvae are supplied to the Head Office; by means of these, detailed control of the work is maintained, and it is found possible in this way to detect readily localities which show signs of being especially heavily infested and if requisite special attention can then be devoted to them.

From the outset the collection and destruction of larvae, by digging them out of the soil in badly infested areas, has formed an essential part of the control measures adopted. As at present conducted, it is principally combined with survey work and is carried out during those months of the year when beetle emergence is at a minimum and the larvae are attaining full growth, *viz.*, May to August. With the gradual spread of *Tiphia parallela*, the introduced parasite, it has been found advisable to restrict the destruction of larvae in localities in which this parasite has established itself, as the indiscriminate destruction of larvae in these circumstances may do more harm than good, owing to the risk of destroying those that are parasitised.

Census work in the infested area has been systematically carried out for some years past. Under this method in every field in the zone 10 to 15 trial holes of a depth of 8 inches are dug in every acre, the larvae found in each hole are counted, and an infestation rate per acre is worked out. The results are subsequently tabulated in the form of a plan, a system of tinting being adopted to indicate varying degrees of infestation. Following this, orders are issued to estate proprietors to dig out the larvae on fields which show more than 20,000 larvae per acre. The prescribed fields are subsequently investigated again after the digging operations have been completed, and if the work has not been satisfactorily performed, the Department of Agriculture is empowered to repeat the process and to charge the estate owner with the cost.

The Introduction of a Natural Parasitic Enemy of the Pest.

The identification by Nowell, in 1912, of *Tiphia parallela* as the principal insect enemy of *Phytalus smithi* in Barbados led to a series of attempts being made between the years 1913–1915 to introduce the insect into Mauritius. A full account of the efforts made in this direction are contained in the paper on this subject previously referred to, published in the Bulletin of Entomological Research.

Since the publication of the paper in question *Tiphia parallela* has established itself firmly at several points in the infested zone and at these points has already exercised a very marked influence on the incidence of the pest. The effect was first seen in 1917 at Esperance estate, where, as the result of the action of the parasite, the total number of adult insects captured in the season 1917–1918 showed a very marked reduction over that of the previous year, the reduction being still more marked in the year 1918–1919. In the year 1918–1919 similar reductions became visible in the case of Maison Blanche estate and also on the group of small properties classed under the head "Small Planters" which occur in this vicinity. During the present season, though completed figures are not available, there is evidence to show that a similar reduction has become evident at Beau Plan Estate; while at Esperance where the insects were formerly present in great numbers they are now only met with occasionally.

The following figures for the number of insects captured at these points during the years 1916–17, 1917–18 and 1918–19 illustrate these remarks :—

Year	Esperance	Maison Blanche	Small Planters
1916–17	21,419,586	—	—
1917–18	7,650,461	1,895,752	8,322,130
1918–19	518,320	937,950	4,303,625

The spread of *Tiphia* throughout the infested area has been systematically assisted by the liberation of insects in places where they did not previously exist. An important point, which has materially assisted in the dissemination of the insects, is the existence of the wild plant *Cordia interrupta* (Herbe Condé), the sweetish exudation from the leaves of which provides food for the *Tiphia* adults. It is also noteworthy that the plant attracts *Phytalus*; in consequence planters are now growing the *Cordia* around the borders of the cane-fields, and this has materially facilitated both the capture of *Phytalus* and the dissemination of *Tiphia*.

Legislative Measures.

Legislative measures for the control of plant pests and diseases are provided under Ordinance No. 8 of 1911.

This ordinance provides for the proclamation of any prescribed area as being infected with plant disease, including both insect and fungous pests, and for the making of general or special orders for the following purposes :—

(*a*) for prescribing or regulating the destruction, removal, uprooting, disposal or treatment of plants and products of a vegetable nature within an infected district, area or place;

(*b*) for prescribing or regulating the cleansing and disinfecting of infected places or areas, or parts thereof;

(*c*) for prescribing the period within which it will not be lawful to plant or replant with any plant whatsoever, or with any particular kind of plant, the whole or any portion of an infected district, area or place;

(*d*) for prohibiting or regulating the movement of persons, animals, earth, soil, manure, vegetable product or other things into or out of a district, area or place declared to be a place infected or suspected of being infested with a plant disease ;

(*e*) for the appointment, pay and regulation of the duties of persons to be charged with the execution of any of the provisions of or orders made by virtue of this Ordinance ;

(*f*) generally for the purpose of in any manner preventing the spreading within the island of any plant disease.

It further provides for the removal of such restrictions in the event of infection being stamped out, for the entry on occupied lands of duly authorised persons for the purpose of examining plants and for carrying out remedial, disinfective or prophylactic measures, for the notification of plant diseases and for penalties for contravention of the provisions of the Ordinance.

Under this Ordinance, Proclamation No. 10 of 1913 prescribed the area infested with *Phytalus smithi*, and made certain orders in relation thereto.

In 1918 the spread of the pest and experience with its control rendered desirable the rectification of the prescribed area and slight modifications in the order ; accordingly the above proclamation was superseded by Proclamation No. 42 of 1918 the terms of which are as follows :—

(*a*) the removal of living specimens of *Phytalus smithi* either larvae, pupae or adults from the area prescribed is prohibited. This, however, shall not apply to the transport of living insects in captivity by properly authorised officers of the Department of Agriculture for purposes of scientific study.

(*b*) the removal of all earth, manure, leaf mould, decayed vegetable matter and all living plants or parts of plants in soil is prohibited from the area prescribed, but the above shall not apply to fruits or vegetables growing above the ground and detachable from the tree or stem on which they grow.

(*c*) cane-tops for propagation purposes in such limited quantities as may be decided upon by the Director of Agriculture may, after examination and disinfection if necessary at Pamplemousses Gardens or at such convenient point as the Director of Agriculture may select, be removed in sealed packages from the infested area.

(*d*) the Director of Agriculture or other person deputed in writing by him may at any time inspect sugar-canes or other crops within the specified area and issue, if considered necessary, an order in writing containing instructions as to the cutting, reaping, disinfection or other treatment of such sugar-canes or crops and as to the disinfection or treatment of the soil in which they are growing. Owners, managers or occupiers shall within 48 hours of such service commence to carry out the treatments ordered, and failing to carry them out, the Director of Agriculture or person aforesaid may cause such treatments to be carried out at the expense of the owner, manager or occupier notified.

(*e*) the Director of Agriculture may plant, raise or cultivate such trees, shrubs or plants as may be deemed expedient for the purpose of attracting or trapping, and may spray or otherwise treat the same for the purpose of destroying the pest. These trees, shrubs or plants shall be protected by the owner, manager or occupier of the land on which they are planted or cultivated for such time as the Director of Agriculture may consider necessary.

The measures above indicated have on the whole provided adequate machinery for the control of the pest. One point, however, requires mention, namely the risk of artificial dissemination of the pest by interested parties, as a result of the policy of buying the beetles. To guard against this a supplementary Ordinance was passed in 1918, whereby any person wilfully disseminating a plant disease is rendered liable to imprisonment without the option of a fine.

Other Methods of Control.

In the early days of the outbreak, a considerable number of experiments were tried on methods of control, other than those enumerated above. These included the trial of various stomach and contact poisons and also the injection of carbon bisulphide and other poisons into the soil. The pest, however, exists in such numbers and on such very extensive areas that the cost of methods of this description renders their employment prohibitive for the most part. The principal methods which have been tried are described below.

Numerous experiments were undertaken at the outset with a view to finding an efficient insecticide, moderate in cost and easily applicable, that would permit of the control of the pest, more particularly on young plantations, as these suffered most from its attacks.

Powder insecticides, such as Paris green and vaporite, proved unsuitable on account of the labour expenses involved in their application. Neither potassium cyanide nor carbon bisulphide could be utilised, not only on account of the expense, but owing also to their harmful effects on plants. Liquid insecticides, involving the use of kerosene, creoline and carbolic acid, though rather expensive, gave more satisfactory results when dealing with young plantations and first ratoons, but their application could not be generalised, in most cases for want of the water needed in their preparation.

Experiments were also tried with the object of finding some substance that would attract the larvae. Good results were obtained with refuse cane-cuttings and tops. These were split in halves and buried in small furrows 2 or 3 inches deep. Every fortnight the furrows were opened, the cuttings turned over and the larvae removed, the same cuttings being replaced and revisited. This method not only allows of the destruction of the pest at a comparatively cheap rate, but also prevents the larvae from entering the planting holes when in search of food.

Other substances such as molasses, ashes, scums, &c., have been experimented with, but without success; attempts were in addition made to infect adults and larvae with cryptogamic diseases. Those affecting larvae proved contagious, but could not be transmitted experimentally; while the one that attacks the beetle and was introduced from Porto Rico (*Metarrhizium anisopliae*) gave poor results. It was found subsequently that this fungus existed already in the Colony, attacking various species of SCARABAEIDAE, but did not exert any very great influence in checking their spread.

The Number of Insects captured and the Results of the Campaign.

The statistics for the number of insects captured afford the best indications of the total prevalence of the pest. These are given below in tabular form, the figures showing both insects and larvae destroyed on all the properties concerned.

Number of Beetles captured from July 1911 to June 1918.

Years	Mon Rocher	The Mount	Maison Blanche	Beau Plan	Espérance	Small Planters	Grande Rosalie	Souvenir	St. André	B-Se-jour	Soli-tude	R. B. Gardens	Total No. of Beetles
1911–12	9,928,152	10,153,414		4,869,262	1,509,359								26,460,187
1912–13	3,222,067	5,777,385		2,609,867	4,436,217								16,045,536
1913–14	4,987,939	20,777,423		5,434,888	5,483,880								36,684,130
1914–15	3,367,321	18,341,588		11,819,986	17,827,512		999*						51,357,406
1915–16	1,423,963	10,529,973		12,612,720	18,560,927		117,546*						43,245,129
1916–17	1,090,771	12,375,758	3,124,980	26,855,150	21,614,016	7,825,295	1,991	24,533	103,597	7,979	853	111,726	73,136,649
1917–18	1,961,791	24,683,033	2,130,916	25,459,114	9,469,111	6,659,050	235,170	142,641	13,851	30,090	2,393	51,234	70,838,394
1918–19	1,621,624	28,786,427	937,950	29,917,740	518,320	4,303,625	660,600	136,150	3,572,150	114,528			70,569,114

Number of Larvae dug out from July 1911 to June 1918.

Years	Mon Rocher	The Mount	Maison Blanche	Beau Plan	Espérance	Small Planters	Grande Rosalie	Souvenir	St. André	R. B. Gardens	Total No. of larvae
1911–12	553,666	106,147			257,125		1,938*				918,876
1912–13	211,818										211,818
1913–14	187,045	1,824,300			25,150						2,036,495
1914–15	347,200	6,164,100		570,050	183,700						7,265,050
1915–16	9,300	1,023,300		2,610,000	3,012,500		39,750*				6,694,850
1916–17		81,200*	326,700		2,645,900	15,800	—		103,597	8,000	3,181,197
1917–18		1,097,900*	4,000	3,071,600	9,000	400	—	13,200	13,851		4,209,951

*Including "Petite Rosalie."

The figures for the 1919–20 campaign are as yet incomplete, but the data so far accumulated appear to give reason for the expectation that the total captures recorded will be markedly less than those of the three preceding years. It will be observed that during the years 1916–17 to 1918–19 the total number of insects captured per annum has remained practically stationary; before that date they showed a fairly steady annual increase, mainly due to the increase of the infested area; while it is clear that the observed check to this increase is the the result of the control measures which have been applied, the actual result experienced is the outcome of a number of superimposed factors. As already pointed out, marked reductions have taken place in the intensity of infestation at Esperance, Maison Blanche and in the case of small planters, largely as the result of the introduction of *Tiphia parallela*. In localities where *Tiphia* has not yet established itself, the tendency is on the whole still slightly towards an increase in numbers, while in addition there is the factor of outward spread, and it is estimated that if *Tiphia* had not been introduced, the insects captured in 1918–19 would probably have totalled 100,000,000. It would appear that collection methods by themselves have proved effective in reducing the incidence of the pest and have greatly mitigated the damage done.

Collection and the work of *Tiphia parallela* combined appear to afford reasonable hope that in infested areas they will ultimately render the incidence of the pest comparatively unimportant. The problem of preventing the spread of the pest to uninfested areas is, however, a difficult one and if this is to be effected, a continuation of some measure of quarantine and peripheral patrol collection seems essential.

Even if *Tiphia* becomes established throughout the whole of the infested area, it can never by its nature establish a complete control of *Phytalus*, since for its existence it is dependent on the production of a supply of beetles each year. It is moreover powerless to check completely the spread of the beetle, since *Tiphia* will naturally congregate where *Phytalus* is plentiful, that is to say, well within the infested area, while the pest spreads at the circumference where the attraction for *Tiphia* is least. Whether in the event of the successful establishment of *Tiphia* throughout the infested area such a slow spread can be regarded in the end with equanimity, it is impossible at the present stage to say. It is, however, quite clear that although the results obtained with *Tiphia* are up to the present in the highest degree encouraging, it is not possible to predict what the future may hold in store for it. No natural enemies of *Tiphia* of any importance are known, but in a foreign environment it is conceivable that hitherto unknown inimical influences may develop; in consequence it would for the present appear unwise to relax the control at present practised and in point of fact more stringent control measures are in contemplation.

The Cost of the Campaign.

The total expenditure on the campaign against *Phytalus smithi* up to 31st December 1919 amounted to Rs.232,100 from funds administered by the Department of Agriculture. Up to the year 1915, the money expended was provided entirely by Government; since then a system of contributions by estate owners has been inaugurated. During the year 1918–19 Government contributions amounted to Rs.24,000 and the estates' contributions to Rs.8,500. Apart from the direct

expenditure, a considerable sum of money has also been spent by estates in operations for beetle destruction, both in labour in the digging out of larvae from infested fields and in the provision of extra premiums, supervision and materials for the work of beetle collection.

Throughout, the closest co-operation has been maintained with the planters concerned, meetings are periodically held for the purpose of discussing plans and details of the campaign with interested proprietors and managers. In this way harmonious and efficient work has been secured, and many obvious administrative difficulties have been successfully avoided or overcome.

Very recently the planting body of the Colony have decided unanimously that, in view of the fact that the pest may be held to constitute a serious menace to the greater part of the sugar industry of the Colony, the entire cost of control should be borne by the planters; and they have recommended to Government the imposition of an export tax of two cents of a rupee per hundred kilos of sugar exported for the purpose of defraying the cost of the campaign.

The sum of money likely to be provided as the result of this measure will suffice for a further extension of activities, and, given the favourable results so far achieved, there is reason for hoping that within a comparatively short period the incidence of the pest may become reduced to comparatively small proportions.

It is impossible to gauge exactly what would have been the effect if these measures of control had not been undertaken. It is, however, certain that the pest would have extended to a very much greater extent than at present, and in badly infested fields would have probably rendered cane-growing impracticable. The lower sugar-growing lands of the island, which provide a suitable environment for *Phytalus*, probably constitute two-thirds of the total cane-growing area; in the absence of rigid control measures it is probable that by now the beetle would have become endemic in the greater part of them. While therefore the exact loss which has been avoided cannot be estimated, one is safe in saying that it would certainly amount to several millions of rupees. On this account the measures taken and the expenditure incurred must be regarded as abundantly justified by the results.

Fig. 1. A night's capture of *Phytalus smithi*.

Fig. 2. Destroying captured beetles by burning.

NOTES ON INSECTS ACCIDENTALLY INTRODUCED INTO THE ISLAND OF MAURITIUS.

By D d'Emmerez de Charmoy,

Government Entomologist.

In respect of insect and, incidentally, fungous diseases of plants, Mauritius is remarkable in two respects ; the first being the very small number that are indigenous to the island, and the second the very large numbers that have been introduced. The desire to introduce exotic plants of a useful or ornamental nature is very widely spread in this Colony, and very extended plant introductions have taken place. Until comparatively recently no restrictions existed on such importations, and as a result insect and fungous pests in large numbers have become established to the great and permanent detriment of the major and minor agricultural industries of the Colony. For example, the cane-sugar industry was threatened with ruin in 1842 as the result of the introduction of the borer, *Proceras sacchariphaga*, Bojer, from Ceylon ; at a somewhat later date great damage was done by the insect known locally as the " Pou a Roche Blanche " (*Pulvinaria gasteralpha*, Icery) ; and again quite recently the introduction of *Phytalus smithi* has proved a serious menace to the industry and has resulted in the loss of large sums of money.

Minor industries have suffered in a corresponding degree. For example, the cultivation of coffee and vanilla has been in large part abandoned, partly as the result of the incidence of introduced cryptogamic diseases ; while in general it has been shown in another paper that out of 80 species of insects recorded as pests of minor crops in the Colony, 50 (or 62·5 per cent.) are of exotic origin.

In relation to official measures of control, the first action taken was in the year 1882, when an ordinance was passed dealing with the introduction of pests of the grape vine, the legislation being the outcome of a convention entered into by the local authorities with the Government of the Cape of Good Hope.

Until 1910, no other protection was afforded ; in this year a second ordinance was passed empowering the Collector of Customs to destroy, or cause to be treated, plants and other articles, the importation of which was liable to lead to the introduction of pests and plant diseases. The ordinance remained inoperative until 1911, when, by proclamation, the powers thereunder were transferred to the Director of Forests.

In 1913, the regulations under these ordinances were again revised, under Proclamation 81 of 1913, whereby the restrictions were made more comprehensive, and executive powers transferred to the Director of the then newly organised Department of Agriculture.

Since that date a regular and efficient control has been exerted over plant importations. The text of the Ordinance and the regulations made thereunder are given as an appendix to this paper.

It is impossible, at the present time, to trace the manner in which many of the older insect pests of crops were introduced into the island, or even to give the exact date of their introduction.

On the other hand, information regarding occurrences during the past twenty years is much more precise and a review of it is of interest, inasmuch as it affords indications of the channels of introduction and the harm that has been caused thereby.

Phytalus smithi.

Though this beetle was detected in Pamplemousses only in the year 1912, there is no doubt that its introduction dates back to at least ten years before its existence was noted. The infested area, the large number of insects destroyed in the first year 1912, the subsequent infestation of other localities, and its rate of spread in these localities, leave no doubt as to the time that the insect must have taken to spread over so large an extent, which in 1912 was about 1 mile in radius.

Though it is impossible to make any definite statement, the probabilities are that the insect was originally introduced through the Royal Botanical Gardens, Pamplemousses, by means of cane plants imported from Barbados, packed in soil in Wardian cases.

A Cecidomyiid Fly.

This Cecidomyiid, which it has not been possible to identify up to now, and the origin of which cannot therefore be traced with certainty, was probably imported in the year 1909 with a lot of mango plants from India by a sugar estate proprietor of Grand Port.

A few years later, the presence of this insect was revealed simultaneously at Port Louis and at Mahebourg, on mango trees, the leaves of which bore small conical galls grouped together irregularly and containing Cecidomyiid larvae. These localities were at first the only two affected, but the infestation was then so widespread that there was no hope of destroying the pest. After having remained localised in these two places until 1918, this fly was found at Grande Rivière, then at Rivière Noire, and can now be seen in almost all localities in the island, in varying numbers.

Dacus d'emmerezi.

This Trypetid fly was described by Professor Bezzi in 1917 in the Bulletin of Entomological Research. It is not an indigenous species, as its presence was only detected in 1915, in the course of investigations concerning *Dacus sygmoides*. It would be difficult to say whence it came, though one might reasonably suppose that it has been introduced from Madagascar by means of cucurbitaceous fruits, as it would have been difficult in infested fruits coming from a more distant place to preserve the healthy appearance which alone could have warranted their safe transit.

This species is nowadays far more common than *Dacus sygmoides*, and exhibits a partiality for marrows and pumpkins, constituting a pest in the cultivation of these vegetables.

Echidnophaga gallinacea.

This flea found its way into Mauritius on fowls imported from Vohemar in 1913, and others which were introduced from South Africa in 1914. The insect proved troublesome at Mapou during the early days of its introduction; it has not spread to the other districts up to now.

Sarcopsylla penetrans.

The jigger has been repeatedly introduced from Madagascar and Farquhar Island since 1910. Rare cases of infection were noticed at Port Louis several years ago. The flea has since never been found elsewhere.

Solenopsis sp. (Red Ant).

It has not been possible to identify this ant up to now, and it is not therefore possible to say what is its country of origin. It is stated to have existed in Pamplemousses for the last twenty years. The writer first encountered it at Rose Hill in the district of Plaines Wilhems some fifteen years ago, when it was only to be found in a few places.

It is now widespread throughout the island, being quite common on the coast and in hot places, where it has become a regular pest; it is still relatively rare in the higher districts, where it has not hitherto attracted special notice. It rarely establishes itself in houses; on the other hand it is a serious pest of food crops wherever it has established itself, building its nests deeply in the soil and extending its subterranean galleries in every direction for long distances. It steals small seeds from seed beds and eats on the spot larger seeds which it cannot carry away; it also attacks young seedlings.

Coccidae.

As one would expect, importations have been more numerous in this family than in any other, not only from the year 1900 but also previous to that date. In a monograph published by the author in 1900, 51 species were mentioned, among which three only could be considered as indigenous. This number has since been increased by eight more; these are:—*Asterolecanium spectabile*, Newst., *Aspidiotus destructor*, Sign., *Aspidiotus mauritianus*, Newst., *Chionaspis simplex*, Green, *Lecanium mangiferae*, Green, *Lecanium hesperidum*, L., *Pulvinaria antigoni*, Green, and *Pulvinaria* sp.

Asterolecanium spectabile and Aspidiotus mauritianus.

These scales were observed for the first time in 1915 in Pamplemousses Gardens and at the Botanic Gardens, Curepipe, on various species of palms and on *Cycas revoluta* and *Cycas* sp. They cause much harm to these plants in spite of the fact that the insects are highly parasitised by various Chalcids during a certain part of the year.

Aspidiotus destructor.

This species also appears to be of relatively recent introduction, as it is only quite lately that guavas, the plants on which they are most abundant, show visible signs of infestation. It is probable that the insect was imported from South Africa, whence a considerable number of plants have been introduced during the last ten years.

Chionaspis simplex.

This species has hitherto been found only on bamboos and is relatively rare, causing no apparent damage to this plant; it presents no importance whatever from an economic standpoint.

Lecanium mangiferae.

The importation of this scale probably does not date back further than 1907, as it was only in 1908 that the first infested trees were recorded in Moka. It would be difficult to state its origin, as the author has observed it in Madagascar and in Réunion in 1917, where many trees, especially mangoes, were severely attacked. In this Colony, it is in Grand Port and especially in the town of Mahebourg that this insect causes most damage. Mangoes, bread-fruits, *Cinnamomum zeylanicum* (cannellier) and litchis are often infested to such a degree that they do not bear fruit for several years. In the north of the island, where it exists, its presence is not apparent, either on account of unfavourable climatic conditions, or owing to a small Chalcid which parasitises it intensely.

Lecanium hesperidum.

It seems curious that this species, the distribution of which is world-wide, should not have been found in Mauritius before 1900. The effects of the insect are so striking that it is inadmissible that it could have escaped the author's notice at the time when this group of insects was being worked upon. It was introduced from the Seychelles or from Madagascar with oranges. On the higher plateaux its presence is hardly perceptible, but it is much in evidence along the coast, where limes, particularly, suffer severely from its attacks.

Pulvinaria antigoni.

This species was introduced some 10 years ago from the Seychelles ; it was first discovered in Pamplemousses Gardens and a little later at Phoenix on *Solanum wildenii* and on *Aristolochia*. It is far from being widespread in the island and is relatively common on these plants for only a few months of the year, being highly parasitised by two minute Chalcids. It is up to now of no economic importance.

Gagrella feae.

This Phalangid, which was imported from Burma some 10 years ago with cargos of rice from Rangoon, is a striking instance of the rapidity with which an exotic insect can spread itself, when conditions prove favourable to its development and when nothing intervenes to check its spread and multiplication. The first specimens were seen by the author in 1910 and had been captured in the town of Port Louis by Mr. Lauricourt Olivia, taxidermist to the Museum. Three years later it had reached Grand River, *i.e.*, 26 miles from the original point of occurrence, and in the course of the five following years, the other districts of the Island had all become more or less invaded ; nowadays it is to be found everywhere. It has established itself in all towns and has crept over to the forests, where it exists in considerable numbers. It is sometimes so common in houses as to constitute a regular domestic pest.

These Phalangids shun light and have the habit of collecting in considerable numbers in dark places. They spread out rapidly whenever they are disturbed, but will come back soon afterwards.

Anoplodesmus saussurei.

This millipede was introduced into the island about 1904–1905, in Wardian cases containing rubber plants imported from Ceylon by an estate situated in Vieux Grand Port district. One year later the writer was in a position to say with certainty that the creatures occupied already the whole mountain range that separates Grand Port district from Flacq, and that the western side was no less infested than the eastern side.

Conclusion.

It follows from the above that within the last 20 years, 14 exotic species of insects are known to have been accidentally introduced into this Colony. Of these 14 species, two have no significance from an economic standpoint; the 12 others have already caused considerable damage.

These facts demonstrate emphatically that the restrictions established through the Department of Agriculture in 1913, though they may hamper to some extent freedom of importation, fulfil an urgent requirement in protecting the agricultural products of this Colony, which in the past have suffered considerable losses that could have been avoided altogether by the adoption of the measures now in force.

APPENDIX.

Ordinance 4 of 1910.

1. In this Ordinance "article" means any seeds, plants, cuttings, or any package, covering or thing that may have come directly or indirectly from any Country or place named in any Proclamation issued under this Ordinance.

2.—(A). It shall be lawful for the Governor in Executive Council by Proclamation to prohibit the importation of any articles from any country or place named in such Proclamation which, in his opinion, are likely to be a means of introducing any plant disease from such country or place.

(B). In like manner the Governor in Executive Council may prescribe the conditions under which alone the importation of any articles shall be permitted that may have come directly or indirectly from any country named in such Proclamation.

3. Any article coming from any country or place the importation from which is prohibited, and any article arriving from a country or place the importation from which is permitted upon certain conditions only, until and unless such conditions shall have been complied with to the satisfaction of the Collector of Customs, shall be deemed to be prohibited goods within the meaning of the Customs Ordinance No. 28 of 1892; and any such conditions as aforesaid shall be deemed to be restrictions within the meaning of the said Ordinance.

4. So long as any Proclamation as aforesaid is in force any articles mentioned therein coming from parts beyond the sea may be deemed to have come from a place the importation from which is prohibited, and may be treated accordingly, unless the importer satisfies the Collector of Customs to the contrary.

Proclamation 81 of 1913 issued under the above Ordinance provides :—

1. The importation into Mauritius from any country or place whatever, including the Dependencies of Mauritius, is absolutely prohibited of :—

(*a*) grape-vine cuttings and plants, except when covered by a certificate from the Board of Agriculture (or other competent authority) of the country of origin that the vines have not been exposed to the infection of phylloxera for the six weeks prior to the date of shipment ;

(*b*) earth, and leaf and garden mould ;

(*c*) sugar-canes or cuttings thereof, live plants of all sorts, including roots, tubers, cuttings and grafts in any description of earth or soil ;

(*d*) dung or animal droppings (except guano) ;

(*e*) forage ;

(*f*) timber with the bark on.

2.—(A). The following articles may not be introduced unless written permission has previously been obtained from the Director of the Department of Agriculture :—

(*a*) sugar-canes or cuttings thereof ;

(*b*) living plants or bulbils of *Agave* or *Fourcroya* ;

(*c*) tea plants.

(B). The issue of a permit shall be in the discretion of the Director of Agriculture, who may attach conditions to the permit and may limit the number of plants, cuttings and others aforesaid to be introduced.

3. The following will be inspected at the port of entry :—

(*a*) sugar-canes or cuttings thereof ;

(*b*) live plants of all sorts, including roots, tubers, cuttings, grafts, and buds ;

(*c*) fresh citrus fruits from all countries except the Dependencies of Mauritius.

The consignee or his agent shall, upon request, open the coverings and afford the inspecting officer every facility for conducting the examination.

4. If, on such inspection, the articles are found to be not free from pest or diseases, they may be ordered to be destroyed by the consignee or his agent under the supervision of the inspecting officer, or to be subjected to such process of disinfection or treatment as the inspecting officer may prescribe, and the consignee or his agent shall pay in respect of such treatment such fees and charges as are prescribed.

5. If the removal is authorised, all sugar-canes or cuttings thereof and live plants of all sorts, including roots, cuttings, grafts, and buds, shall be planted in a nursery apart from growing plants of the same kind and shall be subject to inspection by the Department of Agriculture from time to time during twelve months from the date of importation.

6. If, on such inspection, the articles are found to be not free from pests or diseases not known to occur in the Colony they shall be rooted out and destroyed by the owner under the immediate supervision of the inspecting officer, and if found to be not free from pests or diseases known to occur in the Colony, they shall be so treated by the owner as may be directed by the Director of the Department of Agriculture.

7. Non-compliance with the conditions imposed in articles 4, 5 and 6 with respect to the disinfection, treatment and planting of the articles imported will render them liable to destruction at the expense of the owner.

8. Provided that nothing in the above shall prohibit or prevent the Government from making such importations and introductions of such live plants, cuttings and others aforesaid, as it may require for scientific investigations.

The provision for prohibition of certain imports is to protect our staple industries from pests and diseases which could be introduced in shipments, and which would at the same time be very difficult to detect at the port of entry.

The sugar-cane, fibre and tea industries are also protected against the introduction of pests and diseases by imports only being allowed from countries and localities where serious diseases are non-existent. The Department of Agriculture through its exchanges of scientific publications is well informed of the occurrence of pests and diseases in other countries, and therefore can afford assistance to the principal industries of the Colony by having control of the imports of certain living plants.

Fumigation and disinfection of certain imports after inspection is provided for, in order to safeguard against the introduction of diseases and pests of a cosmopolitan character, and the provision for plantings to be made in nurseries is made so that insects or diseases which may by chance have passed through the port of entry inspections and treatment may be detected before they have become spread in the country.

By Proclamation 52 of 1913 it is provided that the importation into Mauritius from any country or place whatever, including the Dependencies of Mauritius, of all living insects except such as may be required by the Government for scientific purposes is absolutely prohibited.

A PANNIER HOPPER-DOZER.

By C. B. Williams, M.A., F.E.S.,

Department of Agriculture, Trinidad.

(Plate VI).

In the course of my work on the froghopper (*Tomaspis saccharina*, Dist.) damaging sugar-cane in Trinidad, it was found that the adult insects could be caught in very large numbers at the time of their broods by drawing large nets over the cane plants in the late evening and early morning. A number of different types of net were designed and experimented with, and the one described below has proved the most satisfactory up to the present.

Unfortunately, owing to the very limited period of daylight during which the adults can be so caught, the use of these nets as a practical control has not so far been a success. The account below is given entirely in the hope that it may contain some new suggestions that might be applied or adapted to the control of other pests under other conditions.

It was necessary to get a net of good width that could be moved rapidly over canes of various heights, without damaging them, and with the least expenditure of labour. These results were obtained by having two nets in the form of panniers on the sides of an animal (in this case a mule), the whole being wide enough to sweep two rows of cane planted five feet apart when the animal walks between the rows.

Very little description is necessary if the figure and plate are examined carefully. Most of the details are unimportant and could be varied to suit local conditions.

Each net is hinged behind and is supported in front by a stout cord or wire that is attached to the front supporting bar. This is loose in its bearings, and by rotating it the front of the net can be raised or lowered, which can be done by the boy in the saddle, without getting down, as the height of the canes changes. The nets in the machine figured could be lowered so that the bottom edge was only a few inches from the ground, when they could be used in long grass, or raised until there was about three feet clearance. It was not found feasible to send mules through canes requiring the nets higher than this. By removing the stop on the rear bar and unhooking the front supporting cord, each pannier can be removed in less than a minute.

The nets are open in front and may be smeared inside with some sticky substance, or the opening could be fitted with a shutter arrangement of netting to prevent the escape of the insects. In the present machine they are of wire mosquito netting, but strong cloth or even thin wood might be used. The advantage of the net is that it allows the air to pass through, and does not create a back-draught.

The framework of the nets and saddle was constructed of wooden bars, one inch by two inches, while the main supporting bars, rear and front, were one inch iron tubing. The saddle should be well padded and securely strapped down with two girths.

Provided that the nets were not too close to the ground no difficulty was found in taking them over rough ground, open field drains or even small gullies. It need scarcely be added that it is as well to start work gently and with an unusually quiet animal.

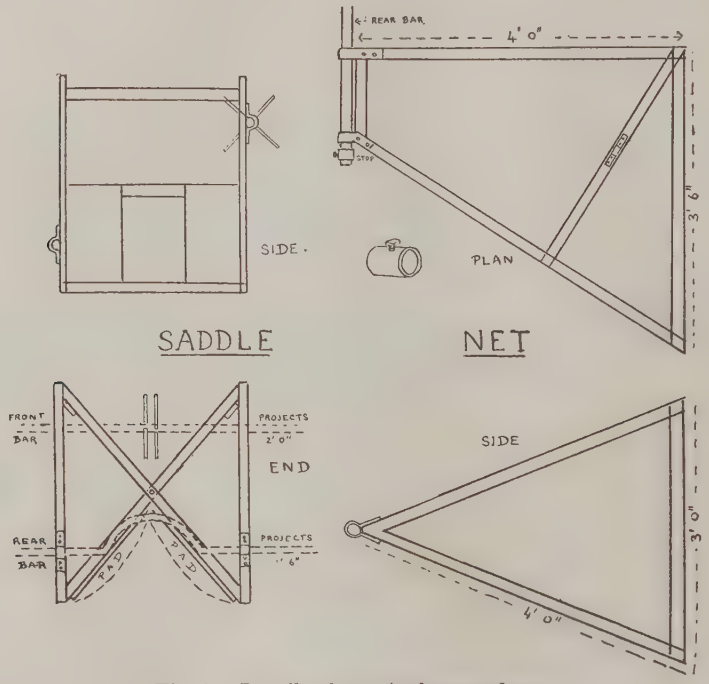

Fig. 1. Details of pannier hopper-dozer.

A LIPARID MOTH (*OCNEROGYIA AMANDA*, STAUD.) DESTRUCTIVE TO FIGS IN MESOPOTAMIA.

By P. A. Buxton, M.A., F.E.S.,

Fellow of Trinity College, Cambridge.

There are few countries in which agriculture is more important and the enemies of the crops less known than Mesopotamia. The following notes on a serious pest of the fig-tree in various parts of the Baghdad vilayet were put together on the River Diyala, north-east of Baghdad, at the end of July 1918. The Liparid moth which is so injurious has been determined by Sir G. F. Hampson as *Ocnerogyia amanda*, Staud. The larvae devoured all the fig leaves completely, with the exception of one or two of the large vascular bundles. The fruit shrivelled and dropped before it was ripe.

Life-History.

The eggs are easily found in patches of from twenty to a hundred, often laid so that they did not touch each other; the groups of eggs are found on the lower parts of the trunks, more rarely on the underside of the lower leaves, and on rubbish on the ground. The female does not deposit her anal hairs upon the eggs. The eggs are large* for the size of the moth (horizontal diameter 1·39 mm., height 1·23 mm.).

As Dr. G. A. K. Marshall has pointed out to me, eggs large in proportion to the size of an insect are generally laid by species which either aestivate or hybernate in the egg stage. This is clearly not the case in the species that we are now considering, which is continuous-brooded.

The larvae are almost entirely night feeders, and conceal themselves before 7.0 a.m. in summer among dead leaves beneath the fig-trees, in cracks in soil or in mud walls and similar situations. They may occasionally be found by day on, and especially under, the leaves in shady parts of the gardens. The hairs of this species produced no urticating effect on my skin, which is however by no means sensitive.

The pupa is placed in cracks in soil, and under overhanging portions of mud walls.

So far as I could detect during my short stay in the area in which I found this species, the two sexes fly with equal readiness if disturbed during the day-time; they do not fly in sunshine unless disturbed.

We have no knowledge of the time of year at which the pest begins to be troublesome. It has been actually observed from the end of July to the end of September. It is apparently a species that breeds continuously during these months, as all the stages can be found at the same time. This is quite unusual, for the very great majority of Mesopotamian Lepidoptera aestivate throughout the summer, which is excessively hot; we do not know whether they go through the summer as eggs or pupae.

* Compare *Orgyia antiqua*, 0·82 by 0·68 mm.; *Liparis monacha*, 1·045 by 0·77 mm.

Distribution.

In the year 1918 *O. amanda* was a very serious pest of figs at Baʿquba (Bakubah) on the River Diyala, about thirty miles north-east of Baghdad ; also at Mendali, Shahroban, and Balad Ruz, all of which are within sixty miles of Baʿquba towards the Persian frontier ; also at Kerbela on the west side of the River Euphrates, 50 miles S.S.W. of Baghdad. This last was important, because the large black figs of Kerbela are famous all over lower Mesopotamia and the whole crop was destroyed by *O. amanda* in 1918. So far as I know, figs, though widely grown, are not a principal crop in any part of the country. The incidence of the pest appears to be very sporadic ; I failed to find it at Khaniqin, about 60 miles up the River Diyala from Baʿquba, or at Baghdad, Basrah, Qurnah, Nasiriyah, or Suq-ash-Shuyukh. In the year 1919, as I am informed by the Director of Agriculture, Baghdad, there were no reports of its incidence in Mesopotamia, and in the same year I failed to find it in North-West Persia at Qazvin and Enzeli, and at Tiflis in Transcaucasia.

The larva is known to the Arab cultivators as Shimbaran, but the word is not in very general use.

Preventive Measures.

The habits of the insect lead us to believe that it should be easy to keep in check, and the following measures may be mentioned :—(1). Arab cultivators burn the dead leaves and other rubbish in heaps beneath the trees. This destroys all stages of the insect, and also its hiding places. The damage done to the tree is slight. (2). Hand-picking the larvae from beneath the leaves shortly after dawn should be effective ; batches of eggs would be found at the same time. (3). Grease banding would no doubt catch the larvae on their morning and evening migrations, but it is unlikely that so expensive a method will be used when burning the rubbish is so efficacious.

Description of the Moth.

When Staudinger described the monotypical genus *Ocnerogyia* he had only the male of the present species before him ; the female has not previously been captured. Sir George Hampson has been good enough to redescribe the species as follows :—

Family Liparidae.

Genus **Ocnerogyia.**

" *Ocnerogyia*, Staud., Iris, iv, p. 254 (1891). Proboscis absent ; palpi very short, porrect, clothed with rough hair ; frons smooth, with large tuft of hair ; eyes rather small and elliptical, smooth ; antennae of male bipectinate with long branches to apex, of female with rather shorter branches ; thorax and abdomen clothed with rough hair and without crests ; tibiae and tarsi moderately fringed with hair, the mid and hind tibiae with terminal pair of spurs. Forewing broad, the costa evenly arched, the apex rounded, the termen obliquely curved and not crenulate ; vein 2 from beyond middle of cell ; 3 from well before angle of cell ; 5 from above angle ; 6 from upper angle ; 7, 8, 9 stalked ; 10, 11 from cell. Hind wing with the cell long ; vein 2 from beyond middle of cell ; 3 from well before angle of cell ; 5 from just above angle ; 6, 7 from upper angle ; 8 connected with the cell by a slight oblique bar just before middle.

Ocnerogyia amanda.

Ocnerogyia amanda, Staud., Iris, iv. p. 254 (1891).

" ♂. Head and thorax grey, tinged with reddish brown the lower part of frons and palpi yellowish ; abdomen fulvous orange. Forewing grey, tinged with reddish brown and irrorated with rather elongate pale griseous scales ; a rather diffused blackish discoidal bar. Hind wing uniform fulvous orange, the cilia brownish grey. Underside of forewing without dark irroration or discoidal bar, a small rather diffused fulvous orange patch below middle of cell ; hind wing with the costal edge brownish grey.

" ♀. Antennae with the shaft whitish ; abdomen pale grey tinged with brown, the basal segments and sides tinged with yellowish ; hind wing pale grey, tinged with brown, the inner area with some pale fulvous hair ; underside of forewing without the fulvous orange patch below the cell.

Exp., ♂ 38, ♀ 40 mm.

Upper Syria : Mardin. Mesopotamia : R. Diyala, Ba'quba (*P. A. Buxton*), 1 ♂, 1 ♀ in Brit. Mus."

Description of the Larva.

The larva presents points of difference from that of other Liparidae, and I have drawn up the following description from spirit specimens in the last instar. Unfortunately I was engaged with other work at the time when I found the larvae, at the height of the Mesopotamian summer ; my notes only say that the skin was grey-green in colour, and that the intersegmental membrane was neither paler nor darker than the rest. The setae were silky and almost colourless. The general appearance is shown in text-fig. 1 (A & B) and suggests an Arctiid rather than a Liparid. There are none of the dense brushes of hair with which we are so familiar in *Orgyia* and *Dasychira*. The larva lacks also what Fracker calls " clavate-plumed setae." The colourless setae are very finely and evenly serrate. It will be noticed that long setae arise from the prothorax (actually from a large verruca formed by the fusion of Kappa and Rho), and curve forwards over the head of the larva ; these setae are more than half the length of the larva, but in fig. 1.B only their basal half is shown. On the meso- and metathorax and abdomen the longest setae grow out sideways on verrucae Kappa and Pai. Among the silky setae a few brown ones (*b.s.*) may with difficulty be found. They are always long and thick, and arise from the large verruca (*g.t.*) (Rho plus Kappa) of the prothorax in some numbers, and as single setae on Beta of the meso-thorax, and Rho on abdominal segments 1–8 inclusive.

Chaetotaxy. The head. All the primary setae of Forbes can be easily seen except ii, v, and vi. The last two are probably present but cannot be distinguished with certainty among the rather large secondary setae which are sparsely scattered over the lower and more lateral parts of the head. There is only one secondary seta on the adfrontal, situated below adfrontal i ; this is fewer than is usual among the Liparidae (Forbes).

The thorax.* On the anterior margin of the prothorax, near the mid-dorsal line is a small group of setae, alpha, beneath it a still smaller group of setae, two or three

* In describing the chaetotaxy of the thorax and abdomen I have followed Fracker's system.

only, gamma. Beta and delta appear to be absent. In front of the large prothoracic spiracle an immense tubercle (*g.t.*) arises, pointing forwards. It is clothed with setae of both types, the brown and the colourless, which are more than half as long as the entire larva, and are directed forwards over the head. This verruca is very well developed in various Liparid larvae which I have examined, and is formed by the fusion of Rho and Kappa. This we see when we compare the prothorax with either of the succeeding segments, in both of which Rho and Kappa are separate. The process of fusion of these two verrucae, so complete on the prothorax, can actually be watched taking place on successive segments of the abdomen. Beneath this very large verruca is a second one, which consists of Pai with its associated setae; this is recognisable in all segments to the ninth abdominal inclusive. Its setae project outwards and downwards and form a conspicuous tuft over the leg on all leg-bearing segments.

Meso- and metathorax. The chaetotaxy is sufficiently shown in text-fig. 1 (B). Rho and Kappa are not fused.

Abdomen. Beta (α, plus β, plus secondary setae) can be seen on each of the first nine segments and is largest on the eight and ninth. The gradual migration of Kappa to a position behind but distinctly above the spiracle is interesting. It never coalesces completely with Rho except on the ninth segment, but the two groups, Rho and Kappa, are borne on one large partly divided verruca on all the abdominal segments. The group which represents sigma consists of many setae, and is borne on a definite verruca on the legless segments (1, 2, 7, 8, and 9); on the other segments it is only to be found with difficulty. No trace can be found of nu, tau, or mu; we presume therefore that they are components of Pai.

The legs and prolegs are covered sparsely with secondary setae which are believed to be of no phylogenetic significance. The prolegs (A and C, *pl.*) are long and armed with long crochets all of one size arranged in a mesoseries, that is to say a curved line concave outwards. On the outer side of all prolegs except the anal pair is a chitinous plate bearing secondary setae. The dorsal glands on abdominal segments 6 and 7 are small; the diameter of the mouth of the gland is less than verruca Beta; these glands are believed to be characteristic of all Liparidae.

The points of interest in the structure of the larva are:—

(1) Liparid larvae fall into two main groups: *Ocnerogyia amanda* falls into the first, many of which are densely hairy like Arctiidae. The second group contains bizarre species armed with dense brushes (verricules) and clavate plumed setae; *Orgyia* is a good and familiar example of this group.

(2) Fracker states that in these insects there are "three verrucae above the Kappa group on the mesothorax and metathorax." Forbes says (p. 103) "five warts on mesothorax." (This comes to the same thing as beneath Kappa lies Pai). *Ocnerogyia amanda* forms an exception to these general statements; as will be seen from text-fig. C, there are only four verrucae on the mesothorax, and metathorax; two of which are above Kappa.

(3) The eversible gland on the mesodorsum of abdominal segments 6 and 7 appears to be the most constant characteristic of the larvae of Liparidae. So far as we know, it is always present, though it may be very small.

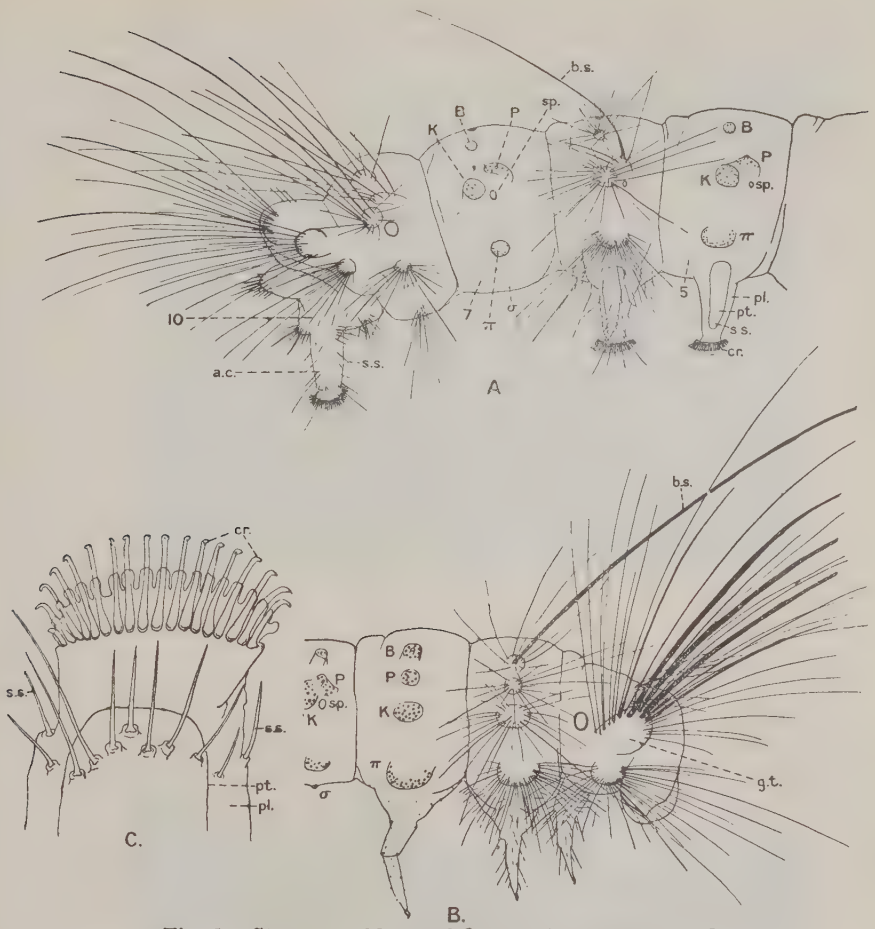

Fig. 1. Structure of larva of *Ocnerogyia amanda*, Staud.

A. Abdominal segments 5–10
B. Head, thorax and abd. segt. i } Magnified by about 35.

In these figures certain segments are shown armed with their setae; others are denuded of setae and show the chaetotaxy diagrammatically. The long setae curving over the head are drawn about half their full length. The head is shown in outline only, without setae, eyes or mouth-parts. On I alpha and gamma are indicated, but are not lettered in order to avoid overcrowding the figure.

C. Proleg of 3rd abdominal segment viewed from side, magnified by 150.

I, II & III. Pro-, meso-, and metathorax; 1–10, abdominal segments; *a.c*, anal clasper; *b.s*, large brown seta; *cr*, crochets arranged in a line concave outwards, all of one size except those at the ends; *g.t*, great tubercle of I; *pl*, proleg; *pt*, plate on lateral side of proleg, bearing secondary setae; *sp*, spiracle; *s.s*, secondary setae; B, Beta bearing alpha plus beta; on I Beta is figured but not lettered to avoid confusion; K, the compound verruca Kappa; II, large compound verruca above the insertion of leg or proleg; P, verruca bearing epsilon plus rho, and fusing with Kappa on I to form *g.t.* and partly fusing with it on 1–9; σ, the nearly midventral sigma, which in this species is represented by a tuft of setae.

In fig. 1. A & B the compound verruca II has been marked π in error.

References.

W. T. M. Forbes (1910). A Structural Study of some Caterpillars.—Ann. Ent. Soc. Amer. iii, pp. 94–132, 11 plates.

S. B. Fracker (1915). The Classification of Lepidopterous Larvae.—Illinois Biolog. Monographs, ii, no. 1, pp. 1–170, 10 plates.

O. Staudinger (1891). Iris, iv, p. 254.

A pannier hopperdozer for catching insects on sugar-cane.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st April and 30th June, 1920, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. E. Ballard, Government Entomologist, Madras :—120 Tabanidae and 69 Tachinidae ; from South India.

Capt. P. J. Barraud, Entomologist to the Egyptian Expeditionary Force :—79 Culicidae, 22 other Diptera, 18 Hymenoptera, 141 Coleoptera, 6 Planipennia, 18 Lepidoptera, 23 Rhynchota, 6 Orthoptera and 92 Odonata ; from Palestine.

Mr. C. F. C. Beeson, Forest Zoologist :—143 Curculionidae ; from India .

Mr. John R. Bovell, Superintendent of Agriculture :—5 Diptera, 16 Hymenoptera, 5 Thysanoptera, 1 species of Coccidae, 6 Aphididae, 6 other Rhynchota, and 5 Acari ; from Barbados.

Major J. E. Boyd :—4 Tachinidae ; from Sandwich, Kent.

Mr. J. B. Corporaal, Entomologist, Algemeen Proefstation, Medan :—12 Diptera, 38 Coleoptera, and 4 Rhynchota ; from Sumatra.

Mr. J. Sydney Dash, Director, Station Agronomique de la Guadeloupe :— 9 *Diaprepes* beetles and 100 Aphididae ; from Guadeloupe.

Division of Entomology, Pretoria :—11 Rhynchota and 21 Orthoptera ; from South Africa.

Dr. D. Duff :—5 *Phlebotomus* ; from Winnebah, Gold Coast.

Dr. Eustace W. Ferguson :—5 Tabanidae, 4 Hippoboscidae, and 41 other Diptera ; from Palestine : 81 Tabanidae ; from Australia.

Dr. Goldberg, Jewish Health Bureau :—1 *Culicoides*, 6 Culicidae and 1 *Lyperosia* ; from Palestine.

Dr. Lewis H. Gough, Government Entomologist :—14 specimens of the butterfly *Catochrysops eleusis* ; from Egpyt.

Hawaiian Sugar Planter's Association :—10 Curculionidae ; from Honolulu.

Dr. J. F. Illingworth :—906 Coleoptera and 8 Rhynchota ; from Queensland.

Imperial Institute :— 10 Hymenoptera ; from Colombia.

Dr. A. Ingram :—11 Culicidae, 9 Dipterous larvae, 238 Fleas, 7 *Hemimerus*, 19 Anoplura, 3 Mites, and 73 Ticks ; from the Gold Coast.

Mr. H. H. King, Government Entomologist :—2 *Tabanus*, 7 other Diptera, 47 Hymenoptera, 26 Coleoptera, 106 Rhynchota, and 10 Crickets ; from the Anglo-Egyptian Sudan.

Dr. W. A. Lamborn:—3,000 Fleas, 60 Chalcids, 317 parasitic Hymenoptera, 145 other Hymenoptera, 9 Thrips, 116 Cimicidae, a number of Aphids, 10 other Rhynchota, 35 Anoplura, 104 Mallophaga, 983 Mites, 1 *Glossina*, 3 *Auchmeromyia*, 282 other Diptera, 270 Dipterous pupae, 155 Ants, 1 Coleopteron, and 1 Lepidopteron; from East Africa.

Dr. J. W. Scott Macfie :—20 *Phlebotomus*, a collection of early stages of *Pericoma*, a number of other Diptera and Ants, and 12 other Hymenoptera ; from the Gold Coast.

Prof. G. H. F. Nuttall, F.R.S. :—2 Hippoboscidae ; from the Belgian Congo.

Dr. H. Schouteden :—9 Hymenoptera, 12 Coleoptera, 23 Moths, and 1 Tettigoniid ; from the Belgian Congo.

Mr. F. V. Theobald :—7 Chalcids (*Pteromalus egregius*) bred from the Brown-tail Moth : from Romney Marsh, Kent.

Dr. B. Uvarov :—A collection of *Phlebotomus* ; from the Caucasus.

Mr. Robert Veitch :—3 *Tabanus*, 5 other Diptera, 179 Coleoptera, and 23 Microlepidoptera ; from Fiji : 7 Diptera, 20 Hymenoptera, and 31 Coleptera ; from New Zealand.

Mr. C. B. Williams :—14 specimens of the Scolytid beetle *Xyleborus grenadensis* ; from Trinidad.

Mr. R. C. Wood :—8 Tabanidae, 91 other Diptera, 298 Coleoptera, and 34 Rhynchota ; from Nyasaland.

SOME NEW WEST INDIAN SPECIES OF THE MELOLONTHID GENUS LACHNOSTERNA.

By Gilbert J. Arrow.

Twenty-four West Indian species of this genus were enumerated in Messrs. Leng and Mutchler's list of 1914, in addition to which four species from Porto Rico have since been named by Mr. Eugene Smyth (Journ. Dept. Agric. Porto Rico, i, 1917). Two other species have been assigned to the genus *Phytalus*, which is distinguished from *Lachnosterna* solely by the claw-tooth making an acute instead of a wide angle with the tip. As H. W. Bates found in his attempt to distribute the Central American species, it is impossible to make this the basis of a natural division, especially as in certain species (as in *L. dilemma* here described) it is confined to the male.

The genus *Phytalus* was constituted by Erichson in 1847 for American and Oriental species, but was restricted to the former by Blanchard in 1850. Blanchard formed for Oriental representatives a new genus *Brahmina*, but without comparing the characters of the two. Brenske in 1892 confirmed this geographical division and set forth characters by which he maintained that a purely American genus *Phytalus* could be separated from the Eastern genera *Brahmina*, *Holotrichia* and others. These characters he defined as—(*a*) cleft claws, the inner branch being as long as or longer than the outer; (*b*) elongate antennal club in the male; (*c*) hollowed abdomen in the male; the opposite conditions denoting the Oriental genus *Brahmina*.

But Brenske's statement of the case really points to the opposite conclusion to that drawn by him, for the application of his tests relegates the West Indian species *Phytalus smithi*, Arrow, and the Mexican *P. omiltemus*, Bates, to the genus *Brahmina*, while the Mexican *P. platyrrhinus*, Bates, combines the characters of the two genera, the inner branch of the claw being much shorter than the outer. As just mentioned, however, the cleft claw may be only a feature of the male sex, so that no single character has yet been found which is sufficient for the recognition of the female *Phytalus*, and those supposed to characterise the male are quite at variance with the present conception of the genus. In my opinion *Phytalus*, *Brahmina* and *Holotrichia* are quite undefinable, and I can see no alternative to treating them as one with *Lachnosterna*.

In recent American works on this group of beetles the generic name *Phyllophaga* has been adopted. This name was introduced by Harris in 1826, eleven years earlier than the date of the characterisation by Hope of *Holotrichia* and *Lachnosterna*. It is however a *nomen nudum*, accompanied by no description, and is therefore upon the same footing as the numerous Catalogue names printed by dealers and others, to which obviously no scientific value can be attached.

Including the five here described, thirty-five species of this genus are now known from the West Indian Islands, and many of them are probably of economic importance.

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Lachnosterna jamaicensis, sp. nov. (fig. 1, *c*).

Castaneo-rufa, nitida, corpore subtus cum pygidio pallide flavo; oblonga, cylindrica, capite fortiter dense punctato, clypeo bilobato; pronoto sat profunde haud crebre, medio paulo parcius, punctato, lateribus medio angulatis, postice fere parallelis, antice convergentibus, vix arcuatis, haud crenatis, angulis anticis fere rectis, posticis obtusis; scutello utrinque minute punctato, medio fere laevi; elytris modice fortiter et crebre punctatis, costa suturali duabusque discoidalibus vix perspicuis; pygidio sat fortiter punctato; pectore dense flavo-villoso; antennis 9-articulatis, clava triphylla.

♂, Antennarum articulo 6° breviter laminato, clava modice elongata; tarsis posticis quam tibiis paulo longioribus: ♀, antennarum clava brevi, tarsis posticis quam tibiis brevioribus.

Long. 17–18 mm.; lat. max. 8·5–9·5 mm.

Jamaica (*A. H. Ritchie*).

It is a rather narrowly elongate insect, of a mahogany-red colour, with the lower surface and pygidium pale yellow. The entire upper surface is shining, but rather strongly punctured, the head densely so. The sides of the prothorax are not crenate and are almost straight from the middle to the front and hind angles.

The description of *L. cylindrica*, Burm., the exact habitat of which is unknown, almost applies to this species, but, although the joint preceding the antennal club of the male has a long sharp process as there described, there is not an abbreviated lamella to the club in addition, nor is the pygidium almost smooth.

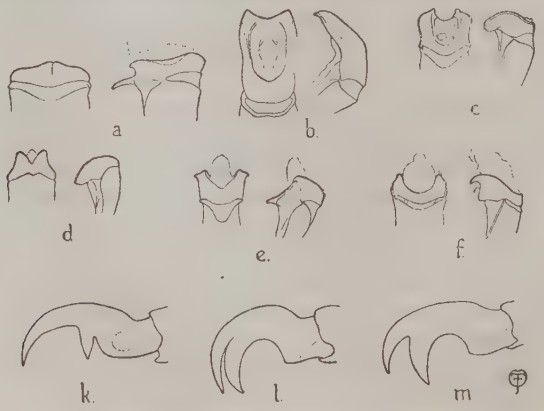

Fig. 1. Dorsal and lateral aspects of aedeagus of male of (*a*) *Lachnosterna dilemma*, sp.n.; (*b*) *L. trinitatis*, Arrow; (*c*) *L. jamaicensis*, sp. n.; (*d*) *L. antiguae*, sp.n.; (*e*) *L. montserratensis*, sp.n.; (*f*) *L. acinosa*, sp.n. Claws of (*k*) *L. montserratensis*; (*l*) *L. dilemma*, ♂; (*m*) *L. dilemma*, ♀.

The only species of the genus hitherto recorded from Jamaica is *L. fervida*, Fabricius, which, although said by its author to be North American, is attributed by Burmeister, who examined the type, to Jamaica and San Domingo. That species has the elytra pubescent and pruinose, while in the new species they are shining and quite devoid of hair.

Lachnosterna montserratensis, sp. nov. (fig. 1, *e*, *k*).

Castaneo-rufa, nitida, elytris abdomineque (cum pygidio) leviter pruinosis, illis parcissime setosis, metasterno dense haud longe flavo-villoso ; oblonga, cylindrica, capite lato, fortiter sat dense aequaliter punctato, clypeo valde bilobato, vix excavato; pronoto aequaliter fortiter punctato, lateribus leviter crenatis, angulis omnibus obtusis, posticis rotundatis ; scutello fortiter punctato, medio fere laevi ; elytris modice fortiter et crebre punctatis, costa suturali duabusque discoidalibus vix perspicuis ; pygidio fortiter punctato ; pedibus gracilibus, unguibus valde dentatis, dente reclinato ; antennis 9-articulatis, clava triphylla.

♂, Clava antennali modice elongata, pedum posticorum calcaribus longis, tarsis quam tibiis longioribus.

Long. 17·5–19 mm. ; lat. max. 9–10 mm.

Montserrat.

In size, colour, sculpture and general appearance this rather closely resembles *L. jamaicensis*, but there are numerous points of difference. There is a rather faint bloom upon the elytra, and this is more apparent upon the pygidium and abdomen. These are also more reddish in colour than in the Jamaican species. The head and pronotum are shining and strongly punctured, as in the latter, but the head is broader, the eyes are larger, the clypeus flatter and more strongly bilobed. The punctures of the pronotum are rather more numerous, the lateral margins are slightly crenate and the hind angles rounded.

I have not seen a female of this species. In the male the 6th joint of the antenna is not produced as in that of *L. jamaicensis*. The claw-tooth is very strong and sharp, inclined a little backwards and separated by a very acute notch from the basal dilatation.

Lachnosterna antiguae, sp. nov. (fig. 1, *d*).

Testaceo-rufa, corpore subtus, pedibus antennisque flavis ; cylindrica, parum elongata, pruinosa, haud nitida, pectore dense abdominisque medio parce flavo-hirto ; capite haud lato, grosse et rugose punctato, clypeo nitido, excavato, bilobato ; pronoto sat fortiter haud crebre punctato, lato, lateribus fortiter arcuatis, vix crenulatis, angulis anticis obtusis, posticis rotundatis ; scutello inaequaliter punctato ; elytris leviter modice crebre punctatis, costa suturali duabusque discoidalibus vix perspicuis ; pygidio paulo densius punctato ; pedibus modice gracilibus, tibiis anticis tridentatis, unguibus medio fortiter dentato ; antennis 9-articulatis, clava triphylla.

♂, Antennarum clava ad stipitem longitudine aequali, articulo 6° brevissime laminato, pedum posticorum tarsis quam tibiis longioribus ; ♀, clava antennali brevi, pedum posticorum tarsis quam tibiis multo brevioribus.

Long. 14–17 mm. ; lat. max. 7–9 mm.

Antigua (*H. A. Tempany*—April ; *H. A. Ballou*—March ; *E. Elridge*—July).

Dominica (*H. A. Ballou*—May).

Beetles and pupae were found in numbers in the soil of the cane-fields in March.

The beetle is testaceous red in colour, its upper surface covered with a dull bloom and the clypeus alone shining (in fresh specimens). The clypeus is rather narrow

and distinctly bilobed, the forehead is rugosely punctured, the pronotum strongly and irregularly, the elytra more finely and closely punctured, and the pygidium still more so.

There is considerable resemblance to *L. denticulata*, Bl., from Martinique, of which M. Lesne has kindly sent me a co-type for comparison, but the new species is less narrowly elongate, the head is relatively narrower, the forehead more coarsely and rugosely punctured, and the sides of the prothorax are less distinctly crenulated. In size, colour and general appearance it also resembles the Mexican *L. anodentata*, Bates, but it is not hairy above. It is also readily distinguishable by the bilobed clypeus.

In the male the club of the antenna is as long as the entire footstalk, in the female about as long as the scape. In the latter the hind tarsi are very short.

Lachnosterna acinosa, sp. nov. (fig. 1, *f*).

Brunnea vel rufo-brunnea, capite et pronoto fuscis, breviter griseo-setosa, pruinosa, sed capite, pronoti parte antica, pygidio pedibusque nitidis, metasterno dense flavo-villoso ; ovalis, convexa, capite haud lato, clypeo brevi, crebre punctato, excavato, margine vix exciso, fronte grosse et rugose punctata, tumida ; pronoto grosse inaequaliter punctato, punctis setis erectis brevibus et longis intermixtis instructis, lateribus medio angulatis, vix crenulatis, haud arcuatis, angulis anticis et posticis fere rectis, anticis autem leviter acuminatis ; scutello elytrisque minute et crebre punctatis, costa suturali aliaque discoidali vix perspicua ; pygidio nitido, subrugose punctato ; antennis 10-articulatis, clava flava ; pedibus utriusque sexus sat gracilibus.

♂, Abdomine medio excavato, segmento penultimo ventrali medio dense spinoso.

Long. 17–19 mm. ; lat. max. 9–10 mm.

Trinidad (*F. W. Urich*).

This is closely related to the Mexican species *L. longipilosa* and *misteca*, of Bates, differing from them most obviously in having the pygidium shining, instead of pruinose. As in those two species the upper surface has both a bluish bloom and a clothing of fine setae, but the bloom is absent from the head and the anterior part of the pronotum. In the male sex the group is also characterised by the hollowed ventral surface of the abdomen and a peculiar spine-studded area in the middle of the penultimate segment.

The head is rather small, the clypeus scarcely notched, and the forehead rugosely punctured. The pronotum is irregularly punctured and bears moderately long erect hairs intermixed with shorter setae. The elytra are rather finely and closely, the pygidium more coarsely, punctured. The antennae are 10-jointed and, like the slender legs, differ little in the two sexes.

Lachnosterna dilemma, sp. nov. (fig. 1, *a*, *l*, *m*).

Nigro-picea, corpore subtus paulo rufescentiore, ubique subtiliter dense griseo-sericea ; ovata, convexa, creberrime punctulata, capite haud magno, grosse et confluenter punctato, clypeo brevi, margine rotundato, reflexo ; pronoto dense minute punctato, angulis anticis paulo acutis, posticis obtusis ; scutello paulo minus dense punctato ; elytris aequaliter dense punctatis, postice setis erectis parce

instructis, costa suturali angusta duabusque discoidalibus parum perspicuis; abdomine linea piligera circumdato, pygidio dense punctato et breviter erecte flavo-pubescente, metasterno dense haud longe pallido-villoso, pedibus modice gracilibus, antennis 10-articulatis, clava triphylla, flava.

♂, Unguibus anguste fissis; ♀, unguibus fortiter dentatis (vel apicibus late divergentibus).

Long. 20–22 mm.; lat. max. 10·5–12 mm.

Trinidad: Verdant Vale (*F. W. Urich*—June).

In size and general appearance this is rather like *L. trinitatis*, Arrow (fig. 1, *b*) from the same island, but *L. dilemma* is more oval in shape, much more finely and closely punctured, especially upon the pronotum, and clothed everywhere with a very fine and close silky grey pubescence. Around the abdomen, at the line of contact with the outer edges of the elytra, the pubescence abruptly ceases and a fringe of long hairs is found. This, so far as I know, does not occur in any allied species.

The abdomen of the male is hollowed beneath and the last ventral segment is concave, smooth and shining, whilst that of the female is convex and strongly punctured. The hind tarsi of the female are little shorter than those of the male, but the tibiae are more dilated at the end and the spurs much shorter and broader. The claws of the male are narrowly cleft, but in the female the two branches diverge widely.

There is considerable resemblance to the Central American *L. setifera*, Burm., but the clothing of the upper surface is finer, the clypeus a little shorter and the angles of the prothorax are less sharp. The male is easily distinguishable by its narrowly cleft claws and the normal straight suture between the last two ventral segments. There is also a resemblance to *L.* (*Phytalus*) *cometes*, Bates, but that is lighter red in colour, rather more elongate, and the abdomen has no line of demarcation between the dorsal and ventral parts corresponding with the outer edges of the elytra.

NOTES ON BLOOD-SUCKING FLIES IN NORTH RUSSIA DURING THE SUMMER OF 1919.

By Major A. D. Fraser, D.S.O., M.C., R.A.M.C.

With an Appendix containing a List of Species, by Major E. E. Austen, D.S.O.

Locality.

Most of the following observations were made in the vicinity of Obozerskaya, a small village on the Archangel-Vologda Railway, 474 versts from Vologda or roughly 80 miles due south of Archangel. I arrived at Obozerskaya and reported to the Headquarters of the Vologda Force on 14th June 1919, a few days after disembarking at Archangel.

Further experience and a few of the specimens collected were obtained during tours of inspection on the Onega River Front in the last week of June, and on the Seletskoe Front early in August.

Nature of Country.

The country in the whole of this district is one continuous forest of pines, firs, etc., and although there is comparatively little undergrowth, any movement through the forest other than along the recognised tracks is rendered extremely difficult on account of the swampy nature of the ground, which remained waterlogged even in July, when the heat was quite trying.

Excepting those along the railway, most of the villages are situated on the banks of rivers or lakes, and around the majority small clearings are cultivated or used for grazing. At Obozerskaya the clearing was very small, and there was no cultivation ; the nearest open water was a lake about two miles from the village. Along one or two of the larger rivers grazing land is more plentiful, and fair-sized herds of cattle are to be seen.

Remarkably few birds or animals of any kind are met with in the forest, though ants are numerous everywhere.

Tabanidae.

Before I arrived in the country mosquitos were numerous and troublesome, and the troops had been provided with mosquito-nets and veils. Midges were also annoying, but otherwise no biting flies were in evidence until 20th June, a warm sunny day following a couple of days of rain, when numbers of Tabanidae appeared. A day or two later they had increased to such an extent that they were present everywhere in swarms, and although at their worst in the forest, they were a pest in the villages, houses, trains, etc. Near the edge of the forest many more than a hundred Tabanids could be counted on one person at the same time, while hundreds of others would be flying around. In the forest itself they were present in almost incredible numbers. There were many officers and men in the Force who had lived and travelled in all parts of the world, but all those I met agreed that never before had they encountered these flies in such swarms.

Soon after the middle of July the flies diminished very considerably in numbers, and during the early part of August only an occasional fly or two would be seen on a particularly bright day.

The flies seemed quite as eager to attack human beings as animals, and at their worst were a greater pest than I have ever found tsetse-flies. The majority of the flies settled on one's legs, and in the forest they attacked in such numbers that work in it was rendered almost impossible. On one occasion I saw Lt.-Col. French, the Chief Liaison Officer, on his return from a reconnaissance through the forest; the backs of his hands and his neck were completely discoloured, and his face was also badly discoloured as a result of bites. He said that as many as fifteen flies at a time would settle on the back of each hand, and his whole attention was occupied in attempting to ward off their attacks.

The officers at Obozerskaya built a wooden tennis-court in the clearing, but the flies attacked so viciously and persistently, even in the evening between 6.0 and 7.0 p.m., that the players were driven from the field, and compelled to give up the game until the flies diminished in numbers.

Towards 10.0 p.m. the flies became less active, and between 10.30 p.m. and 1.30 a.m., when only an occasional fly was to be seen, there was a welcome freedom from their attacks. At this season of the year in North Russia the sun only just dips below the horizon, and it is still quite light at midnight.

The local inhabitants performed most of their outdoor work during the night, and kept their cattle and other animals in their sheds during the heat of the day. When a journey had to be made in the daytime, the drivers of the horses so far as possible selected certain times when they expected a wind would rise and cause the flies to become less troublesome. Before setting out they would rub their ponies with paraffin, a supply of which they would take with them. They would then proceed in convoys and make the journey as quickly as possible, using branches of trees to beat away the flies. The leading horse in the convoy seems to be attacked more severely than the others, and the animal's head appears to be the favourite place of attack; but if blood has been made to ooze from any part of an animal this point always attracts a swarm of flies. As for human beings, I have heard it stated by British officers that they have been bitten through Bedford cord riding breeches. Everyone experienced much discomfort and annoyance from the constant attacks of these flies, and some individuals suffered from bites which developed into nasty septic sores requiring medical attention.

It was noticed that a small, dark-coloured fly (probably a non-biting Muscid) constantly accompanied the Tabanids, and sucked up any blood that flowed from wounds caused by them.

Tabanus.—The flies of this genus were the greatest pest, and always greatly outnumbered those belonging to *Haematopota* and *Chrysops*—at Obozerskaya, when Tabanids were at their worst, by something like 10 or 15 to 1, and 100 or 200 to 1, respectively. *Tabanus* No. 1 [*T. tarandinus*, L.—E.E.A.] was the first to appear, followed a day or two later by *Tabanus* Nos. 6 and 7 [*T. maculicornis*, Ztt., and *T. nigrifacies*, Gob.—E.E.A.]. The vast majority of the flies belonged to these three species until about the end of the first week in July, when they were gradually replaced by others. All these species were widely distributed throughout the district.

Haematopota.—Representatives of this genus were found everywhere, and were most plentiful during the first three weeks in July. From ten to twelve were the most ever seen to settle on one person at the same time. Considering its numbers as compared with those of *Tabanus*, *Haematopota* appeared to be the more active biter.

Chrysops.—First seen in the last week of June, *Chrysops* was met with until the end of the first week of August. Where the forest runs down to the edge of the Maliozerki Lake, as many as four or five of *Chrysops* No. 2 [*C. caecutiens*, L.—E.E.A.] would settle on one at once, but in the forest at some distance from water only one or two of these flies were encountered at a time. They were particularly fond of sitting on one's cap. On cautiously removing my cap, after hearing the fairly characteristic buzz indicating the presence of one of these flies, I more often than not found the insect resting on it.

Owing to their relatively small numbers, and their habit of rarely commencing to bite on first alighting, flies of the genus *Chrysops* were not a very great nuisance,

Blood-Sucking Flies other than Culicidae and Tabanidae. Midges (*Culicoides*) and *Simulium* were troublesome everywhere.

Phlebotomus was not found.

Stomoxys were first seen at the end of June, but it was rather exceptional to come across more than an occasional specimen until August, when they could be found in fair numbers.

Enemies of Blood-sucking Flies. Dragonflies, which were numerous throughout the summer, were frequently seen to capture specimens of the various species of *Tabanus*.

Evidence of Disease. There was no evidence that any of the flies with which this paper is especially concerned conveyed any disease to human beings or domestic animals.

APPENDIX.

(By Major E. E. Austen, D.S.O.).

The interesting statement by Major Fraser printed above confirms what is already known as to the extraordinary abundance and aggressiveness of Tabanidae in Russia. Thus, according to the late Prof. Portschinsky (see Review Appl. Ent., iii, B, pp. 195–196), to whose long-continued researches previous knowledge of the subject is chiefly due, in Russia over 100 species of Tabanidae are found, including some 60 species of *Tabanus*, 18 *Chrysops*, and 6 *Haematopota*, the remainder consisting of representatives of the genera *Nemorius*, *Silvius*, *Pangonia* and *Heptatoma*. In the polar regions of North Russia, where the number of species is limited, those which occur are frequently present in enormous numbers. According to an earlier paper by the same author (see Austen, British Blood-Sucking Flies, p. 33, 1906), in the Gdov District of the Petrograd Government, Tabanidae in summer are so excessively numerous and bloodthirsty that agricultural operations have to be carried out by night; while in parts of Siberia, such as the shores of the River Om, settlers have been compelled entirely to abandon the zone infested by these flies.

The subjoined list, in addition to the names of the species represented in the collection brought back by Major Fraser and presented by him to the British Museum (Natural History), includes, for the sake of completeness, records derived from a study of one or two small series of specimens obtained in North Russia by other collectors during 1918–19, and recently added to the National Collection.

Localities and other data are indicated as follows :—[F.] = Obozerskaya, between 20. vi. and 31. viii. 1919 (*Major Fraser*).

[F¹.] = Chequevo, Onega River, end of June 1919 (*Major Fraser*).

[B.] = 250 miles up R. Dwina, vii. 1919 (*Surg.-Lt. R. Buddle, O.B.E., R.N.*).

[C.] = Kola Gulf, vii. 1918, or other locality and date as stated (*Capt. A. G. Carment, R.A.M.C.*). Presented by Imperial Bureau of Entomology.

[C¹.] = precise locality and date unknown (*Dr. E. A. Cockayne*).

* = determination by Mr. F. W. Edwards.

CHIRONOMIDAE.

Culicoides pulicaris, L.	[F.]
,, sp. incert.—Allied to *C. festivipennis*, Kieff.	[F.]
,, (?) *arcuatus*, Winn.	[F.]
,, *fascipennis*, Staeg.	[F.]

CULICIDAE.

Anopheles maculipennis, Mg.	[F¹.]
Theobaldia siberiensis, Ludlow,* Archangel, 25. ix. 1918.	[C¹.]
Ochlerotatus alpinus, L.,* Murmansk, vi.-vii. 1918.	[C.] [C¹.]
,, *lutescens*, Fabr.,* Archangel, 1918.	[C.]

SIMULIIDAE.

Simulium ornatum, Mg.	[C.] [C¹.] *
,, *reptans*, L.	[C.]
,, *venustum*, Say.	[F.]
,, *latipes*, Mg.	[C¹.]
,, sp. incert., near *S. subexcisum*, Edw.	[C.]
,, *hirtipes*, Fries.	[C.]

TABANIDAE.

Chrysops caecutiens, L.	[F.]
,, *divaricata*, Lw.	[F.]
,, *relicta*, Mg.	[F.]
,, *nigripes*, Ztt.	[C.]
,, *sepulcralis*, Fabr.	[F¹.]
Haematopota pluvialis, L.	[F.] [B.] [C.]
,, *crassicornis*, Whlbg.	[F.]
Tabanus tarandinus, L.	[F.]
,, *tropicus*, Pz.	[F.] [B.] [C.]
,, ,, var. *bisignatus*, Jaenn.	[F¹.]
,, *solstitialis*, Schin.	[F.] [B.]
,, *luridus*, Fln.	[F.] [B.]
,, *nigricornis*, Ztt.	[F.] [F¹.]
,, *borealis*, Mg.	[F.] [C.]
,, *lapponicus*, Whlbg.	[F.]
,, *maculicornis*, Ztt.	[F.]
,, *nigrifacies*, Gob.	[F.]

MUSCIDAE.

Stomoxys calcitrans, L.	[F.]

FURTHER NOTES ON THE LONCHAEIDAE (DIPT.), WITH DESCRIPTION OF NEW SPECIES FROM AFRICA AND ASIA.

By Prof. M. Bezzi,

Turin, Italy.

Having received from the Imperial Bureau of Entomology more material of the family Lonchaeidae, I am in a position to give the following additional notes to my previous paper* on the Ethiopian species.

I think moreover it will be useful to offer a view of the Asiatic and Australian species at present known, as it seems that some of these flies (chiefly those of economic importance) are widely spread over the tropical countries of the Old World. Thus I have now found that the African *plumosissima* lives also in the Philippine Islands; and that the Oriental *citricola* is to be found also in Australia. The wide range of *aurea* (*splendida*) is already known.

The Subgenera of the Genus Lonchaea, s.l.

In my previous paper (pp. 253–254) I have already shown that the genus *Lonchaea* may be divided into three natural groups, which are well characterised structurally and ethologically. These groups may be considered at present as subgenera, but further studies will probably show their generic rank.

For the first group (type *chorea*, Fabr.) and the second group (type *lasiophthalma*, Macq.) there are already the names *Lonchaea, s. str.*, and *Dasyops*, Rond. I will propose here the name *Carpolonchaea*, subgen. nov., for the mainly tropical species of the third group with feathered arista and with two sternopleural bristles (type *plumossissima*, Bezzi). The proposed name indicates the carpophilous habits of these species.

A new subgenus is probably to be erected for the reception of the somewhat aberrant *Lonchaea aurea* (*splendida*), which has a rather isolated position in the genus *Lonchaea, s. str.*, on account of the different form of the head, the peculiar venation of the wings, the metallic colour of the body and the habits of the larva. The name *Lamprolonchaea*, subgen. nov., (type *aurea*=*splendida*) is proposed here for it.

The Ethiopian Species.

In my previous paper 8 Ethiopian species of the genus *Lonchaea* were distinguished; as I have now received 5 other species, thus bringing the total number to 13, the following new table of distinctions is necessary :—

1(4). Antennae very short, widely separated at base, inserted a little below the middle of the eyes, with bare arista; eyes hairy; head considerably broader than the thorax, with a very broad frons in the female, and with short and thin macrochaetae; lunula very broad, open and roughly hairy; cheeks and jowls broad; sternopleurae with a single strong macrochaeta; mesopleurae with anterior macrochaetae not developed; wings shorter than the body, with the second costal cell not dilated outwardly, and with the sixth longitudinal vein destitute of spurious continuation (subgen. *Dasyops*, Rond.).

* This Bulletin ix, 3, March 1919, pp. 241–254, figs. 1–4.

2(3). Cheeks smooth ; tarsi with the 3 or 4 terminal joints black ; base of wings and squamulae yellowish .. .. *mochii*, Bezzi.

3(2). Cheeks rugose ; only the last tarsal joint black ; base of wings and squamulae blackish .. .. *phaeolepis*, sp. n.

4(1). Antennae longer, usually very long, closer together at base and inserted at or distinctly above the middle of the eyes ; eyes bare ; head not or only a little broader than the thorax, with less widened frons in the female, and with well developed macrochaetae ; lunula small, usually less visible and less or not hairy ; cheeks and jowls less broad, usually very narrow ; mesopleurae anteriorly with some strong macrochaetae, which are curved forwards ; wings longer than the body, with the second costal cell dilated outwardly and usually with the sixth vein with a long spurious continuation.

5(16). Arista bare or only microscopically pubescent ; only one sternopleural macrochaeta present ; tarsi always yellow at base ; squamulae whitish and with pale cilia.

6(7). Entire body, except head, of a very glistening green, more or less golden ; antennae short, with the third joint at most twice as long as the basal joints together ; jowls rather broad ; only the basal joint of all the tarsi yellow, with a black tip ; first posterior cell distinctly narrowed at end ; sixth longitudinal vein not at all continued (subgen. *Lamprolonchaea*, nov.) .. .. *aurea*, Macq.

7(6). Body of a shining bluish-black or black colour ; 2 or 3 basal joints of tarsi yellow ; first posterior cell not narrowed at end ; sixth longitudinal vein with spurious continuation (subgen. *Lonchaea*, s. str.).

8(11) Antennae rather short, extending only a little below the middle of the face, with the third joint at most twice as long as the basal joints together ; jowls rather broad.

9(10). Vibrissae not longer than usual ; wings yellowish hyaline . . . *claripennis*, Macq.

10(9). Vibrissae long and strong ; wings brownish .. .. *vibrissifer*, Lamb.

11(8). Antennae long, extending to the epistome, with the third joint many times longer than the basal joints together ; jowls linear.

12(13) Tarsi with only the basal joint yellow ; third antennal joint extending below the mouth-border ; wings brownish .. .. .. *lambiana*, Bezzi.

13(12). Tarsi with 2 or 3 basal joints yellow ; third antennal joint not extending below mouth-border ; wings hyaline, or faintly yellowish on fore half.

14(15). Antennae quite black ; wings slightly yellowish on fore half *continentalis*, sp. n.

15(14). Antennae with the interior part of 2nd and 3rd joint yellowish; wings quite hyaline .. .. *impressifrons*, sp. n.

16(5). Arista plumose or at least long-haired; two strong sternopleural macrochaetae present; antennae always extending to the mouth-border, or even below, with the third joint many times longer than the basal joints together; jowls linear; tarsi entirely black; first posterior cell not narrowed at end (subgen. *Carpolonchaea*, nov). All the Ethiopian species here distinguished have white and pale hairy squamulae, and hyaline or pale yellowish wings.

17(24). Plumosity of the arista of medium length, being not or only a little broader than the breadth of the third antennal joint; the plumules are moreover thin, straight and close together.

18(19). Last abdominal segment of the male longer than the two preceding ones together, deeply incised at end and there with the two points clothed with dense and long, bristly hairs .. .. .. *exci a*, Kert.

19(18). Last abdominal segment of the male not so formed, never specially ciliated.

20(21). Abdomen at end with the two last ventral plates inflated and prominent; smallish species with bare scutellum .. .. *gibbosa*, de Meij.

21(20). Last ventral plates not so formed, never prominent; scutellum more hairy.

22(23). Bluish species of smaller size (not over 4 mm.); plumosity of the arista broader than the breadth of third antennal joint; wings quite hyaline *laevis*, sp. n.

23(22). Black species of greater size, plumosity of the arista as broad as the third antennal joint; wings slightly but distinctly yellowish *ophyroides*, sp. n.

24(17). Plumosity of the arista very long, being twice as broad as the breadth of the third antennal joint; the plumules moreover less thin, undulated and scattered .. .. *plumosissima*, Bezzi.

1. **Lonchaea (Dasyops) phaeolepis,** sp. nov.

Closely allied to *mochii*, Bezzi, from Erythraea, but smaller and at once distinguished by the characters given in the table.

♂ ♀. Length of the body, 3–3·2 mm.; of the wing, 2·9–3 mm.

Head and its appendages as described for *mochii*, with the following differences: the frons lacks the greenish reflexions; the cheeks in the upper part and the sides of frons in the anterior part with rather developed transverse furrows, being thus strongly rugose; arista yellowish at base. Thorax and scutellum without distinct aeneous reflexions, and with the same chaetotaxy. Squamulae blackish, and with a blackish fringed border; halteres black, with paler stalk. Abdomen as in *mochii*, but the ovipositor is distinctly shorter and broader. Legs of all the pairs with the tarsi entirely yellow, the last joint only being black. Wings proportionally shorter and broader, with the base deep blackish to the basal cross-veins; the first posterior cell is not distinctly narrowed at end; the sixth longitudinal vein is shorter.

Type ♂ and type ♀, and a single couple of specimens (British Museum) from Durban, Umbilo, 16.xi.1913 and 23.iii.1914 (*L. Bevis*). In the Cape Museum there is a specimen from Natal.

2. **Lonchaea (Lamprolonchaea) aurea,** Macq.

Of this interesting species I have seen in the Museum of Genoa specimens taken at S. Nicolas and S. Iago, Cape Verde Islands, in May and November 1898, by the late *L. Fea* ; and in the Cape Museum specimens from the Transvaal.

3. **Lonchaea (Lonchaea) continentalis,** sp. nov.

Very closely allied to *lambiana*, Bezzi (*longicornis*, Lamb), from the Seychelles, and perhaps only a continental form of it, but seeming to differ in having the tarsi more broadly yellow at base, and in the wings not being brownish.

♂. Length of the body, 3–3·2 mm. ; of the wing, 3·1-3·3 mm.

Head and its appendages entirely black ; frons proportionally narrow, opaque, with shining vertical plates ; lunula below white, shining ; face quite flat and clothed with whitish dust, which is more shining at sides ; antennae with the third joint extended to the mouth-border and with long, black, microscopically pubescent arista ; palpi broad, with some bristly hairs. Chaetotaxy normal. Thorax and scutellum shining black, not dusted at all, with bluish reflexions on the back ; chaetotaxy normal ; mesopleurae with bristly hairs on the middle, 2–3 bristles curved backwards at hind border, and 2 bristles curved forwards at anterior border ; sternopleurae with only one strong bristle ; scutellum with some hairs at border between the usual bristles. Squamulae white and white-fringed ; halteres black. Abdomen shining black and black-haired ; it has no special ciliation at the tip, nor prominent genitalia ; the last segment is simple and only a little longer than the preceding one. Legs black, with the two basal joints of all the tarsi yellow. Wings hyaline, slightly greyish on the fore half ; second longitudinal vein quite straight ; terminal portions of the 3rd and 4th veins parallel ; small cross-vein a little before the middle of the discoidal cell ; the spurious continuation of the 6th vein is only faintly indicated ; second costal cell with normal dilatation.

Type ♂ and an additional specimen of the same sex (British Museum) from Natal, Durban, 28.ix. 1916 (*C. P. v.d. Merwe*) : another male specimen in the writer's collection from Erythraea, Ghinda, viii. 1916 (*Dr. A. Mochi*).

4. **Lonchaea (Lonchaea) impressifrons,** sp. nov.

Very similar to the preceding species, but of a more glistening bluish colour, with partly reddish antennae and with crystalline wings.

♀. Length of the body, 2·6 mm. ; of the wing, 2·8 mm.

Frons rather narrow for a female, opaque, with shining ocellar and vertical plates ; before the ocelli there is a distinct ovate depression ; lunula shining white ; face rather shining, with a faint greyish dust. Antennae extending to the mouth-border, with the second joint and the rather broad third joint broadly reddish on the interior side, the last only on the basal half ; arista not very long, microscopically pubescent ; palpi and proboscis black. Thorax and scutellum very glistening bluish ; chaetotaxy as in the preceding species, scutellum with 2–3 bristly hairs. Squamulae and halteres as in the preceding. Abdomen very shining, but less bluish than the back of mesonotum ; ovipositor about 1 mm. long. Legs black, the tarsi with the two basal joints and part of the third joint pale yellowish. Wings as in the preceding species, but proportionally broader, they are quite crystalline, even at fore border ; veins very pale yellowish.

Type ♀, a single specimen (British Museum) from Gold Coast, Accra, iv. 1916, " in laboratory " (*Dr. J. W. S. Macfie*).

5. **Lonchaea** (**Carpolonchaea**) **laevis,** sp. nov.

A shining, bluish-black species with quite hyaline wings, distinct in the male sex owing to the not prominent genitalia and the simple last abdominal segment ; from *plumosissima* it is distinguished by its smaller size and the shorter plumosity of the arista.

♂ ♀. Length of the body, 3·5–3·8 mm. ; of the wing, 3·8–4 mm.

Frons black, opaque or with faint sericeous reflexions, the vertical and ocellar plates bluish and shining ; in the female it is only 1½ times as broad as that of the male. Antennae entirely black, with the third joint extended to the epistome, three times as long as the basal joints together ; arista yellowish at base, its plumosity broader than the breadth of the third antennal joint, the plumules close together and straight. Lunula black, but the prominence between the base of the antennae is white-dusted ; face greyish-dusted ; palpi and proboscis black ; jowls linear, vibrissae not specially developed. Thorax very glistening on the back and there with bluish reflexions, black on the pleurae ; mesopleurae on anterior border with 3, and on posterior border with 3 bristles, in the middle with a tuft of bristly hairs ; sternopleurae with 2 strong bristles, which are curved upwards. Scutellum more aeneous, faintly dusted, with short bristly hairs at border. Halteres black ; squamulae white and with white cilia. Abdomen coloured and shining like the back of mesonotum but without bluish reflexions ; last segment of male not elongated or ciliate ; genitalia not visible ; ovipositor as long as the last two segments together. Legs entirely black ; middle femora with complete and long ciliation on hind side. Wings quite hyaline and with pale yellowish veins ; second costal cell very much dilated outwardly ; last portions of 3rd and 4th veins parallel ; small cross-vein before the middle of the discoidal cell and before the end of the first longitudinal vein ; chitinised part of the sixth vein short, but the spurious continuation extended to the hind border ; hind cross-vein quite straight, and longer than its distance from the end of the fifth vein.

Type ♂, type ♀ and an additional specimen (British Museum) from Zanzibar (*Dr. W. M. Aders*) ; some other specimens of both sexes in the writer's collection from Erythraea, Ghinda, August–December 1916 (*Dr. A. Mochi*).

6. **Lonchaea** (**Carpolonchaea**) **ophyroides,** sp. nov.

Also closely allied to *plumosissima*, but easily distinguishable on account of its greater size and the much shorter plumosity of the arista.

♂ ♀. Lengths of the body, 4·2—4·5 mm. ; of the wing, 4·5—4·8 mm.

Head as described for *plumosissima*, but the antennae with the third joint not extending below the oral margin, and with the arista much more shortly plumose, the breadth of the plumosity being not broader than the breadth of the third antennal joint and the plumules being thin, dense, and quite straight. All the rest of the body, legs and wings as in *plumosissima* ; but the abdomen is aeneous, without bluish reflexions ; the ciliation at hind side of middle femora is more developed ; the wings are distinctly yellowish-fuscous on the fore half.

Type ♂, type ♀ and an additional female specimen (British Museum) from British East Africa, Kabete, 28.viii.1914 "on window" (*T. J. Anderson*); a female specimen without antennae from N. Nigeria, Zarda, "ovipositing in vegetable marrow" (*P. H. Lamb*) seems also to belong here.

7. **Lonchaea (Carpolonchaea) plumosissima,** Bezzi.

In fully coloured specimens the wings are sometimes yellowish fuscous on the fore half.

There are specimens from the type locality, Gold Coast, Aburi, January–February 1911, "from kola pod" (*L. Armstrong*); and from the same locality, 1912–13 (*W. H. Patterson*); and moreover a male specimen from British East Africa, Embu, 24.viii.1914 (*G. St. J. Orde-Browne*); thus showing that the species is present even in the east of the Ethiopian Region.

Puparium. Of the specimens reared from kola pods there is also a puparium, this is elongate, about 4 mm. long, of a shining reddish colour; the segmentation is not well marked; the skin is hard, finely rugulose; the posterior spiracular tubercles are small, black, rounded, approximated, and projecting for about the length of their diameter.

The Indo-Australian Species.

The Indo-Australian species of *Lonchaea, s.l.*, were tabulated by Dr. Kertész as long ago as 1901; many species have been added since by Prof. de Meijere and by me. All the subgenera are well represented, with the exception of the subgenus *Dasyops*, of which no Oriental or Australian species are at present known; even in the very numerous Dipterous galls from Java, described by W. and J. Docters van Leeuwen-Reijnvaan, 1901–1916, it seems that there are no galls referable to these flies.

The species at present known, with the addition of some new ones, can be distinguished as follows:—

1(8). Arista bare or only microscopically pubescent; only one sternopleural bristle; legs always with the tarsi partly yellow; squamulae white or pale yellowish and with whitish cilia.*

2(3). Metallic species of golden green colour, with rather short antennae and rather broad jowls; first posterior cell distinctly narrowed at end; tarsi with only the basal joint yellow, with a black tip . . . *aurea*, Macq.

3(2). Black or bluish-black species with narrow jowls and long antennae, the third joint of which is many times longer than the basal ones and reaches the epistome; first posterior cell not narrowed at end; tarsi more broadly yellow.

4(5). Only the basal joint of all the tarsi yellow, but that entirely so; wings yellowish; species more than 4 mm. long .. .. *megacera*, Kert.

5(4). The second joint of all the tarsi also yellow; wings wholly hyaline; species not over 3 mm. long.

* The *Lonchea? consentanea*, Walker 1860, from Macassar and Gilolo, of which the author says nothing about the colour of tarsi, is described as having *white halteres*, and thus cannot be a member of this genus.

6(7). Hypopygium very small, without prominent appendages; thorax black; jowls rather broad .. .. *minuta*, de Meij.

7(6). Hypopygium with a long curved appendage below; thorax aeneous; jowls linear .. .. *pugionata*, de Meij.

8(1). Arista more or less plumose, even if sometimes rather shortly; two sternopleural bristles; legs with entirely black tarsi (with the single exception of *pallicarpa*); jowls always narrow; antennae always long, with the third joint many times longer than the basal joints together and reaching the epistome.*

9(20). Squamulae dark or blackish, and with blackish cilia; thorax and scutellum never pollinose.

10(13). Wings hyaline and with pale yellowish veins.

11(12). Arista with long plumosity; scutellum with numerous bristly hairs at border between the usual bristles; length of body about 5 mm. *citricola*, Bezzi, ♂.

12(11). Arista with shorter plumosity; scutellum with a few short hairs near the apex; length of body about 3 mm. .. .. *ficiperda*, Bezzi, ♂.

13.10). Wings very dark, blackish or brownish, with dark veins.

14(15). Third antennal joint a little yellowish near the base; hypopygium with a broad and strong appendage below; smaller species, about 3 mm. long. *cupraria*, de Meij. ♂.

15(14). Third antennal joint quite black; hypopygium not so formed, without prominent appendage below, species 4–5 mm. long.

16(17). Abdomen violaceous, shining.. .. .. *birói*, Kert. ♂.

17(16). Abdomen black. .. ..

18(19). Abdomen rather opaque in the middle .. .. *atratula*, Walk. ♂.†

19(18). Abdomen entirely shining .. .. .. *obscuripennis*, de Meij. ♂.

20(9). Squamulae white or pale yellowish, with whitish cilia.

21(22). Tarsi yellowish; scutellum bare; wings broad, with the third longitudinal vein ending before the tip of wing .. .. *pallicarpa*, sp. nov.

22(21). Tarsi entirely black; wings less broad, with the third vein ending at tip of wing.

23(26). Arista rather shortly plumose, the breadth of the plumosity being narrower than the breadth of the third antennal joint; scutellum not or less pilose.

24(25). Thorax and scutellum not pollinose; 3 mm. .. .. *calva*, Bezzi.

25(24). Thorax posteriorly and scutellum pollinose; 4 mm. .. *pollinosa*, Kert.

26(23). Arista with longer plumosity, which is at least as broad as the third joint.

27(28). Abdomen dull black, a little shining towards the base of the sides; 3 mm. *montana*, Brun.

* The species *Lonchaea? punctipennis*, Walker 1860, from Macassar, and *Lonchaea? inops*, Walker 1859, from Aru, Mysol and Ceram, evidently do not belong to the present genus.

†Walker, who describes only the female, says nothing about the colour of the squamulae, which are assumed here to be blackish (according to the colour of the wings), at least in the male sex.

28(27). Abdomen entirely shining.

29(38). End of the abdomen in the male without special conformation and without prominent genitalia.*

30(37). Plumosity of the arista not twice as broad as the third antennal joint, with straight plumules.

31(32). Wings brownish, darker on the fore border and apical half.
albisquama, Kert.

32(31). Wings hyaline or more or less deep yellowish.

33(36). Species of greater size (4–5 mm.), with deep yellow wings.

34(35). Frons of the female with 3 longitudinal furrows .. *cyaneonitens*, Kert.

35(34). Frons of the female with 2 furrows only .. .. *bisulcata*, sp. nov.

36(33). Species of smaller size (3·5 mm.), with hyaline or slightly yellowish wings; frons of the female not distinctly sulcate .. *filifera*, Bezzi.

37(30). Plumosity of the arista twice as broad as the third joint, with undulate scattered plumules .. .. *plumosissima*, Bezzi.

38(29). Abdomen of the male at end with special conformation or with prominent genitalia.

39(40). Last abdominal segment of the male twice as long as the preceding one, deeply excised at end and there with the 2 points clothed with long bristly hairs; hypopygium small .. .. *excisa*, Kert.

40(39). Last abdominal segment not so elongate and not excised at end.

41(42). Last abdominal segment simple, but with long black hairs at sides, ciliated; hypopygium small and not prominent below, but with a horizontally produced middle appendage .. .. .. *setifera*, de Meij.

42(41). Last abdominal segment not specially ciliated at sides; hypopygium very prominent below.

43(44). Hypopygium properly small, but the last two ventral segments inflated and prominent in the shape of a rounded protuberance.
gibbosa, de Meij.

44(43). Abdomen at end not gibbous beneath, but the genitalia prominent in the shape of a broad and stout appendage, which is bilobate at end
lucens, de Meij.

1. **Lonchaea (Lamprolonchaea) aurea,** Macq. 1851.

Lonchaea splendida, Loew, 1873.

Lonchaea metatarsata, Kertész, Term. Füzet., xxiv, 1901, p. 83; de Meijere, Tijds. v. Ent., li, 1908, p. 133; liii, 1910, p. 117; lviii, 1915, p. 90; lx, 1918, p. 350; Edwards, Trans. Zool. Soc., xx, 1915, p. 422.

This little fly seems to be the most widely spread species of its genus; in the Orient it is recorded from South India. The synonymy with *metatarsata* is quite certain, as I have seen a specimen from Batavia (*Jacobson*) in the Indian Museum, determined by Prof. de Meijere. *L. metatarsata* was originally described from New

* Of *cyaneonitens* and *bisulcata* only the females are known; the males are here assumed to have a simple abdomen.

Guinea, and Prof. de Meijere has recorded it from Java and Sumatra. *L. splendida* is recorded from Australia, New South Wales ; and Froggatt (Austr. Insects, 1908, p. 308) says that it has a wide range from the Pacific Islands and New Zealand, over Australia ; thus the *L. splendida*, Broun 1905, for which I have proposed the new name of *brouniana*, is probably the same species.

I have before me specimens from the Philippine Islands : Luzon, Laguna, Los Baños and Mt. Maquiling (*C. F. Baker*;) and Panay Culasi, vi. 1918 (*R. C. MacGregor*).

2. **Lonchaea** (**Lonchaea**) **minuta,** de Meijere.

Lonchaea minuta, de Meijere, Tijds. v. Ent., liii, 1910, p. 116, and lx, 1918, p. 350.

Described from Java, I have before me a specimen from Malacca, Kelantan, and another from the Philippines, Batbatan Isl., vi. 1918 (*R. C. MacGregor*).

3. **Lonchaea** (**Carpolonchaea**) **citricola,** Bezzi.

Lonchaea citricola, Bezzi, Philipp. Jl. Sci., viii, D., 1913, p. 319.

Of this species, described from the Philippines, Los Baños,there are in the collection submitted to me by the Imperial Bureau two male specimens from Australia, N. Territories, Darwin, 11.v.1914 (*G. F. Hill*). They agree perfectly with the types, and have been bred from larvae from rotten oranges.

4. **Lonchaea** (**Carpolonchaea**) **ficiperda,** Bezzi.

Lonchaea ficiperda, Bezzi, Philipp. Jl. Sci., viii, D., 1913, p. 320.

I have seen other specimens of this species, likewise from the Philippines, Batbatan Isl., vi. 1918 (*R. C. MacGregor*).

5. **Lonchaea** (**Carpolonchaea**) **atratula,** Walker.

Lonchaea atratula, Walker, Proc. Linn. Soc. Zool., iv, 1860, p. 146 ; Kertész, Term. Füzet., xxiv, 1901, p. 84.

If I have correctly interpreted this species, it is distinguished by its greater size, blackish and dark-fringed squamulae, blackish wings and the dullish disc of the abdomen. It is probable that *biroi*, Kert. from New Guinea, and *obscuripennis*, de Meij., from Java, belong to this same species.

Originally described from Macassar, I have seen specimens from Singapore (*C. F. Baker*) and from the Philippines, Mindanao, Butuan (*C. F. Baker*).

6. **Lonchaea** (**Carpolonchaea**) **pallicarpa,** sp. nov.

Very distinct from all the other known species of the subgenus *Carpolonchaea* from the Old World on account of the yellowish tarsi ; characteristic are also the broad wings, with diverging third and fourth veins.

♀. Length of the body, 3 mm. ; of the wing, 3·2 mm.

Head black ; frons flat, not sulcate, broad, being only a little longer than broad, with sericeous reflexions on the middle, and with glistening and bluish vertical plates. Antennae black, with the third joint a little brownish along the inner border and reaching the epistoma, being about three times as long as the basal joints; arista with long plumosity which is as broad as the breadth of the third antennal joint ;

the plumules thin and straight. Vibrissae and lateral bristles of the mouth-border but little developed ; palpi and proboscis black. Thorax black and very shining, with distinct bluish reflexions on the back ; dorsal hairs very short ; chaetotaxy normal ; mesopleurae with two anter or and three posterior bristles ; two strong sternopleural bristles. Scutellum rather aeneous and faintly dusted, quite bare except for the usual bristles ; squamulae white and white-fringed ; halteres black. Abdomen like the mesonotum, but without bluish reflexions ; ovipositor 1 mm. long. Legs black, with the two basal joints of all the tarsi reddish yellow ; middle femora with complete ciliation on hind border. Wings proportionally broad, quite hyaline, with pale yellowish veins ; the terminal portions of the 2nd, 3rd and 4th veins are straight, gradually and equally diverging, so that the third ends a little before the tip of the wing ; small cross-vein before the middle of the discoidal cell ; hind cross-vein straight, only a little longer than its distance from the end of the fifth vein, sixth vein with spurious continuation to the hind border.

Type ♀, a single specimen in Prof. Baker's collection from the Philippines, Baguio, Benguet (*C. F. Baker*).

7. **Lonchaea** (**Carpolonchaea**) **bisulcata,** sp. nov.

A shining black species of proportionally greater size, with deep yellow wings; distinguished by the bisulcate frons of the female.

♀. Length of the body, 4 mm. ; of the wing, 4·2 mm.

Frons proportionally narrow, a little less than twice as long as broad ; it is dullish black, with sericeous reflexions and with shining black vertical plates ; in front of the ocellar plate there is a rounded depression, from the sides of which emerge two rather deep furrows, which converge towards the antennae, ending separately at the upper border of the lunula. Antennae wanting in the type. Face black, greyish-dusted, with rather shining antennal grooves ; cheeks linear ; jowls narrow ; palpi and proboscis black ; chaetotaxy normal. Thorax shining black, with no distinct bluish reflexions ; chaetotaxy normal ; two equally strong sternopleural bristles. Scutellum aeneous and faintly dusted, with numerous bristly hairs between the usual bristles. Squamulae yellow, with pale yellowish cilia ; halteres black. Abdomen coloured and shining like the mesonotum, with black hairs and short black bristles on the sides ; ventral membrane broad and reddish, ventral plates shining black ; ovipositor short, as long as the last two abdominal segments together. Legs entirely black ; middle femora with rather short but complete ciliation on hind side. Wings yellowish, deeper yellow at base and on fore half ; veins yellowish. but the costa appearing darker on account of its short black ciliation ; second costal cell but little widened outwardly ; terminal portions of third and fourth veins parallel, not diverging ; small cross-vein before the middle of the discoidal cell ; hind cross-vein straight, about twice as long as its distance from the end of the fifth vein ; sixth vein with spurious continuation.

Type ♀, a single specimen in the writer's collection from South India, Trichinopoly, 1911 (*F. Cajus*); the chaetotaxy of the thorax and the black tarsi, in spite of the want of the antennae, show that the species belongs to the subgenus *Carpolonchaea.*

The present species may be the Indian *Lonchaea* without specific name figured by Howlett in Maxwell-Lefroy, Indian Insect Life, 1909, p. 636, fig. 420, from Pusa,

of which he says, " fairly common blue-black *Lonchaea* sometimes seen sitting on leaves in the neighbourhood of excrement." But these last words may prove that it is a *Lonchaea, s. str.*

8. **Lonchaea** (**Carpolonchaea**) **filifera,** Bezzi.

Lonchaea filifera, Bezzi, Philipp. Jl. Sci., viii, D., 1913, p. 320.

Of this species, which seems to be common in the Philippine Islands, I have seen other specimens from Luzon, Laguna, Los Baños and Mt. Maquiling (*C. F. Baker*), and from Manila, x. 1918 (*R. C. MacGregor*).

The yellow penis is not always visible ; the female is characterised by the broad, dull black frons.

9. **Lonchaea** (**Carpolonchaea**) **plumosissima,** Bezzi, 1919.

Of this African species I have seen a male specimen from the Philippines, Luzon, Los Baños (*C. F. Baker*), which agrees perfectly in the arista with the typical specimens from the Gold Coast ; it has a deep black, quite opaque frons, and the wings deep yellowish-fuscous on the fore half.

10. **Lonchaea** (**Carpolonchaea**) **excisa,** Kertész.

Lonchaea excisa, Kertész, Term. Füzet., xxiv, 1901, p. 87 ; de Meijere, Tijds. v. Ent., li. 1908, p. 133 ; liii, 1910, p. 118, pl. 7, fig. 50 ; lx, 1918, p. 350.

Of this, in the male sex, very characteristic species, originally described from Singapore and recorded from Java and Simalur, there are in the Imperial Bureau Collection specimens from Ceylon, Peradeniya, 1918 (*N. K. Jardine*), and from the same locality, 8.vi.1915 (*Green*) ; also from South India, Coimbatore, 17.vii.1912. In the Philippines it is a common species, caught in different localities of Luzon and of Mindanao by *C. F. Baker* and *R. C. MacGregor* ; I have also seen specimens taken at Singapore by Prof. Baker.

11. **Lonchaea** (**Carpolonchaea**) **setifera,** de Meijere.

Lonchaea setifera, de Meijere, Tijds. v. Ent., liii, 1910, p. 119, pl. vii, fig. 52 ; lx, 1918, p. 350.

Even this species, described from Java and recorded from Simalur and New Guinea, is common in the Philippines, as I have seen specimens from Los Baños and Mt. Maquiling (*C. F. Baker*) ; from Manila (*R. C. MacGregor*) ; from Leyte, Tacloban (*C. F. Baker.*)

12. **Lonchaea** (**Carpolonchaea**) **lucens,** de Meijere.

Lonchaea lucens, de Meijere, Tijd. v. Entom., liii, 1910, p. 118, pl. vii, fig. 51 ; lx, 1918, p. 350.

Originally described from Java and recorded from Sumatra, I have seen specimens from the Philippines : Luzon, Los Baños (*C. F. Baker*) and Panay, Culasi, v. 1918 (*R. C. MacGregor*).

On the Females of the Subgenus Carpolonchaea from the Orient.

The females of this group are for the most part unknown, even Prof. de Meijere having described only males. Those known to me are not easy to distinguish. I have not seen females of the species with dark squamulae, except that of my *ficiperda*, which has however whitish squamulae ; it is therefore possible that even the species *citricola* and *atratula* have the squamulae differently coloured in the two sexes. Of *birói*, *cupraria* and *obscuripennis* only the males are known ; of *atratula*, Walker, the author has described the female, but it is possible that he was mistaken as to the sex of his specimen.

The females known to me may be distinguished as follows :

1(2). Arista with very short plumosity, which is much narrower than the breadth of the third antennal joint .. .. *calva*, Bezzi.

2(1). Plumosity of the arista longer, at least equal to the breadth of the third antennal joint, or nearly so.

3(4). Tarsi yellowish ; frons broad ; third and fourth longitudinal veins diverging *pallicarpa*, Bezzi.

4(3). Tarsi quite black ; third and fourth veins parallel at end.

5(16). Plumosity of the arista not twice the breadth of the third antennal joint, with straight plumules.

6(11). Frons broad, not twice as long as broad.

7(8.) Frons of an opaque, deep black colour ; arista rather shortly plumose *filifera*, Bezzi.

8(7). Frons rather shining, with sericeous reflexions ; arista with longer plumosity.

9(10). Wings yellowish fuscous .. .. *lucens*, de Meij.

10(9). Wings hyaline .. .. *setifera*, de Meij.

11(6). Frons narrower, twice as long as broad.

12(13). Ovipositor about as long as the abdomen .. .. .. *ficiperda*, Bezzi.

13(12). Ovipositor much shorter than the abdomen.

14(15). Wings deep yellowish ; frons with a deep depression and with two longitudinal furrows converging anteriorly ; species of greater size *bisulcata*, Bezzi.

15(14). Wings hyaline or slightly yellowish ; frons without basal depression and without marked furrows ; species of smaller size .. *excisa*, Kert.

16(5). Plumosity of the arista twice as long as the breadth of the third antennal joint, with undulated plumules, which are more thick and more scattered than usual ; frons narrow .. .. .. *plumosissima*, Bezzi.

ON THE BRITISH SPECIES OF SIMULIUM.—II. THE EARLY STAGES; WITH CORRECTIONS AND ADDITIONS TO PART I.

By F. W. Edwards.

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In the introduction to the first part of this paper* it was remarked that very little exact work had been published on the adult European Simuliidae. This is equally true of the larvae and pupae; in fact no one has attempted to describe the early stages of more than two or three of the common species. Moreover, in spite of their great interest, and the ease with which they can be collected and reared, they have apparently been almost entirely ignored by collectors, so that whereas in publishing my previous work I was able to acknowledge valuable assistance from a number of fellow entomologists, the results given in the following pages are, unless otherwise stated, due to my own observations. I wish especially to thank Mr. M. E. Mosely for the early stages of *S. subornatum*, the last species to come under my notice in the pupal stage. While there are still many important gaps in our knowledge which remain to be filled, it has been thought worth while to state without further delay the results that have been obtained so far.

The purpose of the present paper is to give the writer's observations on the biology of the insects, and to characterise, sufficiently for purposes of identification, the known larvae and pupae. In the course of rearing some species from the pupae, it was discovered that the females of the *latipes* group had been associated previously with the wrong males, and their characters had been badly confused, both in my original paper and in the reprint of it which appeared in the Entomologists' Monthly Magazine. Owing to this somewhat serious error, which has led the writer to adopt a different interpretation of Fries' *S. aureum*, and owing also to the discovery of four apparently new species, it has been thought advisable to tabulate afresh the adults of both sexes. I am indebted to Mons. E. Ségny, of the Paris Museum, for examining at my request Meigen's types of *Simulium*; he reports that in *ornatum*, *reptans*, *argyreatum*, *sericatum* and *latipes* of Meigen, the types agree with the interpretation here given.

From the systematists' point of view the most valuable memoirs which have appeared dealing with the early stages of *Simulium* are those of Lutz†, Malloch‡ and Pomeroy§ on the American species. To all these writers the present author is glad to express his indebtedness. As regards the early stages of the Simuliidae outside Britain and North and South America, they are still scarcely known, though Mr. Pomeroy has lately undertaken the study of the African species.‖

* Bull. Ent. Res., vi, pp. 23–42 (1915).

† Lutz, A., Mem. Inst. Oswaldo Cruz, i, p. 124 (1909), and ii, p. 213 (1910).

‡ Malloch, J. R. "American Black Flies or Buffalo Gnats."—U.S. Dept. Agric. Bur. of Ent. Tech. Series 26, 1914.

§ Pomeroy, A. W. J. "Notes on five North American Buffalo Gnats of the genus *Simulium*."—U.S. Dept. Agric. Bull. 329, 1916.

‖ While this work has been passing through the press a valuable paper on the German species has been published by Dr. K. Friedrichs (Vorläuf. Mitt. Sitzb. Abh. Naturf. Ges. Rostock, vii, pp. 211–226, Oct. 1920). The adults, pupae and habitats of nine species are briefly described).

Before passing to tabulate the species and consider them individually there are a few points which seem to be of sufficient general interest to claim attention here.

Method of Rearing and of Association of Larvae and Pupae with Adults.–It was pointed out by Newstead* that the pupae of *Simulium* when removed from the water and placed in a moderately damp atmosphere without superfluous moisture will readily complete their transformation into adults. This method of rearing has proved invaluable, and provided the vessel in which the pupae are kept is not too small, and is kept slightly moist, it practically never fails : thousands of specimens have been reared in this way. If however a male pupa which it is desired to rear should die, it can easily be identified by dissecting out the genitalia.

In a colony of larvae where even a moderate proportion are full-grown, some are sure to be found which exhibit a round black spot on each side of the prothorax, conspicuous even to the naked eye. This is the respiratory organ of the developing pupa showing through the larval skin, its component filaments being coiled up into a small space. The filaments can be very easily dissected out with a pair of needles, and a positive identification of larva and pupa obtained. If in the same colony there are also blackish, well-developed pupae, the species can be identified by dissecting these without the necessity of waiting for specimens to hatch out. It is very desirable to identify larvae by this reliable method, since one very frequently finds several species living together in the same colony; though in a small area of a few square inches one will usually greatly outnumber the others.

Over-wintering.—Some species, notably *S. ornatum*, appear to continue breeding throughout the winter, even in the coldest weather, though, as might be expected, the rate of development is greatly retarded. Of such species there must be at least three broods in the year. Others, such as *S. latipes*, pass the ~~winter~~ as young larvae, developing rapidly in the early spring ; probably these are normally single-brooded. The species which appear in such vast numbers in spring in our muddy-bottomed rivers may possibly winter in the mud in the egg stage, but I have not been able to obtain any positive evidence of this. Another possibility, and perhaps a more likely one, is that the females may hibernate, but I have never found them in a torpid state. However, as Mr. Hamm has pointed out to me, the specimens of *S. equinum* and *S. argyreatum* captured very early in the year are generally, if not always females. More observations are needed on this point.

Oviposition.—Very little is yet known as to the egg-laying habits of the different species, but it would seem that great variation exists. I have been able to confirm the very interesting observations of Mr. H. Britten† on *S. equinum*, and have added some further particulars below. I have also found and hatched the eggs of *S. aureum*, which, unlike those of *S. equinum*, are hard-shelled and not enclosed in a mass of jelly; the newly-hatched larva of this species also has a much more strongly-developed egg-burster, so that it would seem that this species may be adapted to resist desiccation in the egg state.

Habitat of Larvae.—The larvae which I have met with may be classified according to their habitat into (1) those which live on water-plants (or other objects if available)

* Ann. Trop. Med., i, p. 40.

† Ent. Mo. Mag. (3), i, 1915, p. 150.

in sluggish and permanent rivers such as those of East Anglia ; (2) those which live on rocks, stones (chiefly the upper sides) and sometimes on water-plants in swift mountain streams, which may become dry in dry seasons ; and (3) those which live chiefly on the undersides of stones, in small temporary streams, which are dry for several months of the year. These classes are not rigidly defined, either in regard to the water-courses or to the insects, but it is often possible to say from the appearance of a stream what species will be found in it. Some, for example *S. latipes*, are more particular in their choice of a locality than others, such as *S. ornatum*, which is perhaps the most catholic in its tastes. The different species found in one type of stream are not all closely related, as is shown by a study of the adults and pupae ; but it is a noteworthy fact that most of the larvae which live in very rapid streams have their anal gills very much branched, while most of those which live in sluggish rivers have the three main branches simple. It might have been supposed that the more rapidly-moving and presumably more highly aerated water would not need such a large surface in the gills for the insects to accomplish their respiration, but this is not what we actually find. It may be that the presence of water-plants assists respiration to an even greater extent than movement of the water.

Larvae always occur in the greatest numbers in the swiftest part of whatever stream they are in. The slow-river species furthermore show a decided preference for those water-plants (e.g., *Scirpus*, *Sparganium* and *Ranunculus*) which have long and narrow or much divided leaves, the reason perhaps being that such leaves are waved about by the current and thus provide better aeration ; the larvae occur most abundantly towards the tips of the leaves.

The species found on stones all show a decided preference for clean stones ; when there is much moss or algal growth or accumulation of sediment on the stones *Simulium* larvae are not often found in numbers. This may perhaps be due to the growth affording shelter for predaceous insect enemies. It is also very noticeable that *Simulium* larvae are never very abundant in those stony streams where there are large numbers of a certain small caddis-worm which lives in pebbly cases attached to the stones.

Larval Moults and Growth Changes.—I have been able to follow the entire larval development in only one species, *S. latipes*, but it will probably be safe to regard this as typical of all in respect to the number of moults and the principal developments which take place in the larval stage. In this species there are six moults, the change to the pupa taking place at the sixth. The first-stage larva is readily distinguishable from the others by the presence of the egg-burster, a small chitinous tooth near the posterior end of the clypeus, it being much more strongly developed* in *S. latipes* and *S. aureum* than in *S. venustum* (?) ; in the former it is plainly visible under a $\frac{2}{3}''$ objective as a dark spot in the middle of the back of the head ; in the latter it is only discernible with a higher power. The first-stage larva is also characterised by one or two pairs of small hairs on each side of the egg-burster , which disappear after the first moult ; by the smaller number of elements in the mouth-brushes and in the

* The actual tooth is no larger, but is darker in colour and surrounded by a darker and more strongly chitinised area of the general integument of the head. In this respect *Simulium* differs strikingly from the CULICIDAE, in which the egg-burster is surrounded by a membranous area.

anal sucker—in *S. latipes* about 15 mouth-brush hairs and about 4 teeth in each sucker-row ; and by the apparently two-jointed antennae, the second joint being the minute cone-shaped one. The later stages differ from one another chiefly in the size of the head, and in the progressively greater number of hairs in the mouth-brush and teeth in the sucker-rows. The full-grown larva of *S. latipes* has about 40 hairs in the mouth-brush and 12–15 teeth in the sucker-rows. The anal gills in this species are quite simple in the first three larval stages, very slightly branched in the fourth, and distinctly so in the last. In this species, as in several others, the head is much darker in colour in the younger larvae, and the markings are less distinct.

Diagnostic Characters of Larvae and Pupae.—It is not the writer's intention to describe the early stages in any detail, but merely to indicate the main points of difference between them. In the larvae these are to be found chiefly in the number of joints in the antennae, in the form of the anal gills, in the markings of the head, and to some extent in the colour of the body. The structure of the mentum and the number of hooks in the anal sucker also vary much with the different species, and some use has had to be made of these points. The mandibles and maxillae certainly exhibit good specific characters, but these have been ignored, as the more obvious distinctions are sufficient to separate all the British species. In the pupae the only characters of systematic value are the form of the cocoon and of the prothoracic respiratory filaments, but these are often so well-defined that they form a much easier means of identifying the insect than any characters of the adult ; they have the advantage of being entirely uninfluenced by sex, and are subject to very little variation.

Seasonal Variation.—The occurrence of definite seasonal variation in the Diptera is only known in a very few instances. The only two cases, so far as I am aware, in which it is regarded as proved, have been recorded by Hensel* for *Dryomyza flaveola*, and by Aldrich† for *Cerodonta dorsalis*. It has also been suggested by Verrall that *Tipula oleracea* and *T. paludosa* may be summer and autumn forms of the same species, but this is not definitely established.

In the case of *Simulium* the spring brood of *S. equinum* is conspicuously larger than the subsequent broods, while there may also be a slight difference in *S. ornatum* ; but this latter is such a variable species that it is difficult to say for certain. In *S. argyreatum*, however, we have a well-marked case of seasonal variation, as both males and females of the spring brood are fairly readily distinguishable by colour and markings, as well as by their larger size, from the later broods ; the spring form is described below as var. *sericatum*, Mg. For absolute proof that these two forms are really the same species it would of course be necessary to breed one from the other, which I have not been able to do, but still I think the assumption may be justified for the following reasons :—(1) the male genitalia are peculiar and are identical in structure in the two forms, which are also alike in all other structural characters ; (2) in any locality where one form occurs the other may also be found ; (3) the spring form is never found after about the middle of May, and the summer form never before the beginning of that month.

* Berl. Ent. Zeit., 1870, p. 133.
† Ann. Ent. Soc. Amer., xi, 1918, p. 63.

Blood-sucking Habits.—In my previous contribution I stated that some of our commonest species were probably not bloodsuckers, but this opinion has since proved to be quite erroneous, as I have had abundant evidence that both *S. ornatum* and *S. latipes* will attack man ; and though there are still species (such as *S. aureum*) against which there is no evidence, it will probably be safe to assume that all the species may on occasion develop this habit. It would seem that their blood-sucking propensity depends much more on the weather than on the particular species ; a still, warm and sunny afternoon in April or May, and perhaps to a somewhat less extent later in the year, will always rouse them to activity. Some further details on this subject are given in the sequel.

Range of Flight.—It has often been observed that *Simulium* may be found at considerable distances from their breeding places, and though this may in part be due to some stream having dried up and so been overlooked by the observer, yet it is certain that these insects can fly long distances. I have frequently taken *S. ornatum* and other species at a distance of a mile from the nearest possible breeding place, while on one occasion I took *S. venustum* on Birds Hill, near Clothall, Herts., two miles from its home in the river Ivel. This power of flight is not by any means confined to females in search of food, as most of my records of specimens taken far from their breeding haunts are of small swarms of males.

Parasites and Associates.—E. H. Strickland* has described in detail three parasites of *Simulium* larvae in North America : a worm of the genus *Mermis*, the sporozoans *Gluglea* spp., and an undetermined Gregarine. I have found what appear to be these same parasites in various species in this country, though the parasitised specimens are never in very large numbers, *Mermis* in particular being rarely met with. As observed by Strickland, parasitised individuals are generally much above the average size.

It may also be of interest to note that small Chironomid larvae are frequently found within the cocoons, particularly of *S. ornatum*. I believe these are the larvae of a small species of *Orthocladius*, the cocoons of which are often to be seen lying close against the side of a *Simulium* cocoon. Whether the Chironomid is dependent upon the *Simulium* or whether it also occurs away from them I have not been able to ascertain.

Simulium as Food for Fish.—From the immense numbers in which larvae and pupae of *Simulium* occur in many rivers, it might be imagined that they would form an important part of the diet of fish, but in the case of trout at least this does not seem to be so. I have examined the stomach-contents of a number of trout obtained by Mr. M. E. Mosely, and found very few *Simulium* larvae or pupae among them. In so far as the genus was represented at all, it was mostly by adults (chiefly males) of *S. ornatum* and *S. equinum*. Mr. Mosely suggests that this would be accounted for by the habits of the trout, which feeds mostly at the surface or by suction from the bottom. The adult flies found would be those which had fallen into the water : among these, males from dancing swarms would no doubt be in excess. As noted below under *S. tredecimatum*, one case has been observed in which large numbers of *Simulium* larvae were found in the stomach of a trout.

* Jl. Morph., Philadelphia, xxiv, 1913, pp. 43–105.

*Control Measures.**—As has been pointed out by several previous writers, the best method for reducing the numbers of *Simulium* is the cutting and removal of weeds in rivers and streams; to be effective this should be done in March. This method would not affect those species which live chiefly on stones, such as *S. reptans*, *S. tuberosum* and *S. latipes*. Probably all that could be done to check these species would be the removal of the most heavily infested stones; the densest colonies could easily be discovered, as they are usually to be found mainly at certain favourable spots.

Tabulation of Species.

Adult Males.

1. Front metatarsi more or less flattened in a vertical plane; front tibiae, and usually also the thorax and abdomen, with silvery markings; claspers flattened dorso-ventrally (Group A) .. .. 2.
   Front metatarsi cylindrical; front tibiae, thorax and abdomen without silvery markings, though the tibiae may have silvery pubescence; claspers not flattened (Group B) .. .. 11.
2. Hind metatarsi distinctly thickened in a vertical plane; pubescence of thorax somewhat coarser; claspers three times as long as broad .. .. 3.
   Hind metatarsi slender, nearly cylindrical; pubescence of thorax very fine; claspers hardly longer than broad .. .. 10.
3. Hind tibiae on basal $\frac{1}{3}$, metatarsi on basal $\frac{1}{2}$, conspicuously pale .. .. 4.
   Hind tibiae and metatarsi all black, or nearly so .. .. 6.
4. Membranous area of pleura with soft hairs; front metatarsi 5 times as long as broad .. .. *ornatum*, Mg.
   Membranous area of pleura quite bare (even when freshly emerged); front metatarsi about $6\frac{1}{2}$ times as long as broad .. .. 5.
5. Clasper rather slender, external margin slightly concave, the spine terminal *variegatum*, Mg.
   Clasper broader, external margin strongly convex in the middle, the spine subterminal .. .. *monticola*, Fried.
6. Middle tibiae conspicuously yellowish at base .. .. 7.
   Middle tibiae all black .. .. 8.
7. Front metatarsi about $5\frac{1}{2}$ times as long as broad; silvery markings of thorax inconspicuous; stylus of adminiculum hairy .. *subornatum*, sp. n.
   Front metatarsi about 4 times as long as broad; two conspicuous rounded silvery spots on thorax; stylus of adminiculum bare .. *reptans*, L.
8. Front tibiae conspicuously silvery in front .. .. 9.
   Silvering of front tibiae much less conspicuous; clasper rather slender on apical half, with a dorsally-projecting thumb-like process near the base *tuberosum*, Ldst.

* These are well summarised by Wilhelmi in a recent German Government publication (Die Kriebelmückenplage; Uebersicht über die Simuliidenkunde, besonders in practischen Hinsicht. Jena, Oct. 1920).

9. Clasper shaped much as in *tuberosum*, but somewhat broader, and thumb-like process shorter; adminiculum differing from *tuberosum* and resembling the following .. .. .. *venustum*, Say (=*austeni*, Edw.).

Clasper much broader, without sub-basal thumb-like process and without articulated spine .. .. *morsitans*, Edw.

10. A pair of lateral, almost triangular, silvery markings on front of mesonotum *argyreatum* (Mg.) Ldst.

These markings greyish, not silvery and continued backwards as two narrow lines to the hind margin of the mesonotum *argyreatum* var. *sericatum*, Mg.

11. Venation normal: second joint of hind tarsi more or less excavated above near the base; legs not densely hairy .. .. 12.

Venation abnormal, an extra vein (R_{4+5}) present: second joint of hind tarsi cylindrical; legs with long and rather dense hair *hirtipes*, Fries.

12. Hind metatarsi almost cylindrical, and conspicuously pale towards the base; membranous area of pleura with soft hairs .. *equinum* (L.) Edw.

Hind metatarsi more or less thickened vertically: entirely dark in colour; membranous area of pleura quite bare .. .. 13.

13. Pubescence of thorax golden: second hind tarsal joint deeply excavated.. 14.

Pubescence of thorax dull whitish yellow; second hind tarsal joint only slightly excavated .. .. *subexcisum*, Edw.

14. Hind metatarsi barely three times as long as broad .. .. *latipes*. Mg.

Hind metatarsi quite four times as long as broad .. .. 15.

15. Clasper nearly cylindrical, of even width throughout .. *angustitarsis*. Ldst.

Clasper much swollen towards the base, and rather short *aureum*, Fries. (=*bracteatum*, Coq.; =*angustipes*, Edw.).

Adult Females.

1. Front metatarsi flattened in a vertical plane: front tibiae, and sometimes the thorax, with silvery markings: last three abdominal tergites shining (Group A) .. .. 2.

Front metatarsi cylindrical: front tibiae and thorax without silvery markings, though the former may have silvery pubescence; last three abdominal tergites dull (Group B) .. .. 12.

2. Frons (above antennae) and face (below antennae) grey, dull .. .. 3.

Frons blackish, shining (face usually grey) .. .. 5.

3. Claws with a small sharp tooth just before the middle .. .. .. 4.

Claws not toothed; coloration like *ornatum*; membranous area of pleura bare *subornatum*, sp. n.

4 Femora mainly dark; membranous area of pleura with soft hairs; front metatarsi 5×1 .. .. *ornatum*, Mg.

Front and middle femora almost all yellow; membranous area of pleura bare; front metatarsi 6·5×1 .. .. *variegatum*, Mg.

5. Claws toothed ; thoracic markings as in *ornatum* .. .. 6.
   Claws simple ; thoracic markings different, or absent .. .. .. 7.
6. Membranous area of pleura with soft hairs .. *ornatum* var. *nitidifrons*, n.
   Membranous area of pleura bare .. .. .. *monticola*, Fried.
7. Face black, shining, like the frons ; legs mainly black .. *tuberosum*, Ldst.
   Face grey ; legs more extensively pale .. .. 8.
8. Thorax almost dull, with coarser pubescence .. .. 9.
   Thorax somewhat shining, with much finer pubescence .. .. .. 11.
9. Basal two-thirds of hind tibiae clear yellow .. .. *reptans*, L.
   Basal half of hind tibiae yellow, but less sharply distinguished from the black apical portion .. .. 10.

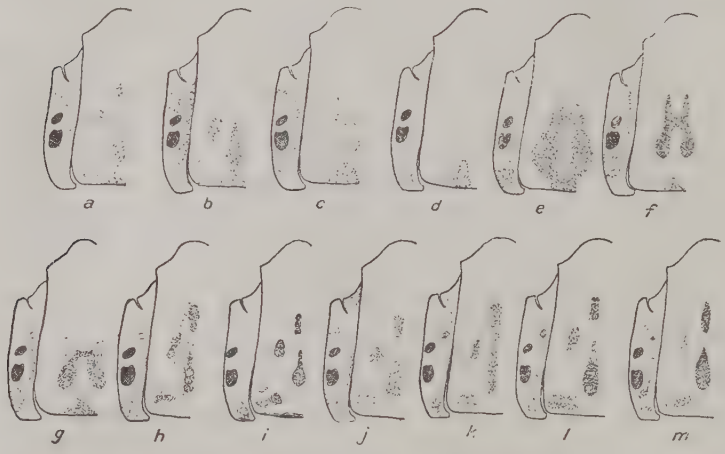

Fig. 1. Head markings of *Simulium* larvae (the markings vary a good deal in intensity in most species ; individuals have in each case been chosen which showed the markings most strongly developed. The figures are somewhat diagrammatic and not strictly to scale) : *a, S. ornatum* ; *b, S. variegatum* and *S. monticola* ; *c, S. subornatum* ; *d, S. reptans* ; *e, S. reptans* var. *galeratum* ; *f, S. morsitans* ; *g, S. venustum* ; *h, S. argyreatum* ; *i, S. equinum* ; *j, S. latipes* ; *k, S. aureum* ; *l, S. angustitarsis* ; *m, S. subexcisum.*

10. Rather less than basal half of mid tibiae yellowish *venustum*, Say (=*austeni*, Edw.).
    Rather more than half of mid tibiae yellowish .. .. *morsitans*, Edw.
11. Thorax brightly shining ; front coxae reddish .. *argyreatum* (Mg.) Ldst.
    Thorax less shining, with traces of the two greyish longitudinal stripes seen in the male ; front coxae blackish .. *argyreatum* var. *sericatum*, Mg.
12. Vein R_{2+3} absent (normal) ; second joint of hind tarsi more or less excavated above near the base .. .. 13.
    Vein R_{2+3} present ; second joint of hind tarsi cylindrical ; claws simple and rather small .. .. *hirtipes*, Fries.

13. Claws simple and very large ; thorax with three narrow black lines (hidden in good specimens by golden pubescence) .. .. *equinum* (L.) Edw.
Claws smaller and with a large basal thumb-like projection ; thorax unstriped 14.

14. Pubescence of thorax golden or brassy ; second hind tarsal joint deeply excavated .. .. 15.
Pubescence of thorax and abdomen dull yellowish-white ; second hind tarsal joint only slightly excavated .. .. 17.

15. Pubescence of abdomen very scanty, hairlike and whitish ; abdomen pink in life ; legs nearly all black .. .. *latipes*, Mg.
Pubescence of abdomen dense, scale-like and golden ; abdomen yellowish in life .. .. 16.

16. Femora and tibiae clear yellow with black tips .. .. *aureum*, Fries.
Femora and tibiae darker, the latter with a dark ring close to the base *angustitarsis*, Ldst.

17. Pubescence of thorax all pale .. .. *subexcisum*, Edw.
Pubescence of thorax with three dark stripes, the middle one divided by a line of pale hair-like scales .. .. *yerburyi*, sp. n

Full-grown Larvae.

1. Antennae 4, 5, or 6 jointed, though the division between the first two, three or four is somewhat obscure .. .. 2.
Antennae 3 or 9 jointed .. .. 16.

2. Last abdominal segment rounded ventrally, or with only very small papillae ; antennae usually 5 jointed .. .. 3.
Last abdominal segment with a pair of large conical papillae ; antennae 4-jointed, but very long and slender .. .. 14.

3. The three anal gills simple (sometimes with a few short branches in *galeratum*) 4.
Anal gills each with 5–10 branches* (4 or 5 in *reptans*) .. .. .. 9.

4. Anal sucker with 100 or more rows of hooks, 18–25 hooks in each row .. 5.
Anal sucker with 65–80 rows of hooks, 12–18 hooks in each row ; body not bright green ; dark "eyebrows" present .. .. 6.

5. Central and lateral teeth of mentum enlarged ; head markings distinct, but dark eyebrow absent ; body bright green .. .. .. *equinum*, L.
All teeth of mentum small ; head markings very indistinct, but a dark eyebrow present ; body colour uncertain .. .. .. *tredecimatum*, sp. n.

6. Abdomen without distinct banding ; skin round anus with numerous minute trifid spines .. .. 7.
Abdomen with a distinct dark band on each segment dorsally ; skin round anus nearly bare .. .. 8.

* When the gills are branched they are much less frequently retracted than when they are simple. The gills of *S. subornatum* have not been observed ; since they were retracted in all the specimens examined, they are probably simple.

7. Head markings as in fig. 1*a* ; anal spines very numerous and dark *ornatum*, Mg.

Head markings as in fig. 1*c* ; anal spines less numerous .. *subornatum*, sp. n.

8. Back of head with a large roundish black area .. *reptans*, var. *galeratum*, n.

Back of head with four elongate dark spots, usually enclosed in a suffused brownish area .. .. *argyreatum*, Mg.

9. Larger species ; gills with 8–10 branches ; abdominal banding inconspicuous or absent ; dark " eyebrow " usually conspicuous ; clypeal markings of the *ornatum* type though often indistinct (cf. also *subornatum*, with different head marking) .. .. 10.

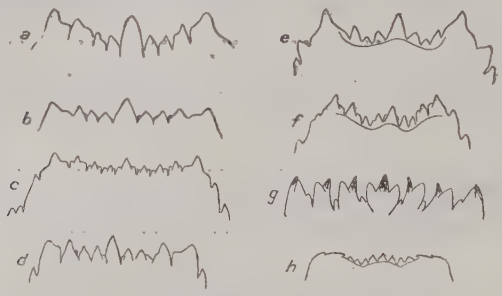

Fig. 2. Apex of mentum of *Simulium* larvae ; all × 150. *a, S. ornatum* ; *b, S. subornatum* ; *c, S. reptans* ; *d, S. equinum* ; *e, S. latipes* ; *f, S. subexcisum* ; *g, S. hirtipes* (after Malloch) ; *h, S. tredecimatum*. The hairs on the sides of the mentum are not shown, but are of diagnostic importance, as described in the text.

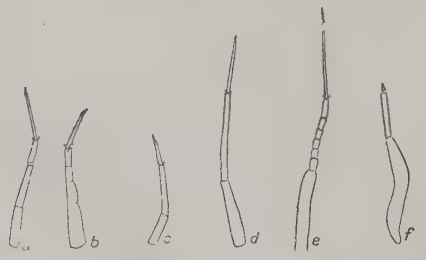

Fig. 3. Antennae of *Simulium* larvae ; all × 50. *a, S. ornatum* ; *b, S. subornatum* ; *c, S. equinum* ; *d, S. latipes* ; *e, S. subexcisum* ; *f, S. hirtipes* (this last after Johannsen).

Smaller species ; gills with 4–6 (rarely 8) branches ; abdominal banding usually conspicuous ; dark " eyebrow " usually absent ; clypeal markings various but never of the *ornatum* type .. .. 11.

10. Thoracic proleg with strong chitinisations behind the circle of hooks . . . *variegatum*, Mg.

These chitinisations much less evident ; skin round anus with more numerous scales .. .. *monticola*, Fried.

11. Clypeus with a single dark spot posteriorly, or none .. .. .. 12.
Clypeus otherwise marked .. .. 13.

12. A dark area in middle of posterior margin of clypeus, and another on each side of the head before the eyes; body colour greenish.. *reptans*, L.
Head all pale; body colour greyish .. .. *tuberosum*, Ldst.

13. A large black mark in the form of an H near the middle of the clypeus; body colour yellowish-green .. .. *morsitans*, Edw.
A pair of dark spots on clypeus, more or less connected anteriorly; body colour bright green .. .. *venustum*, Say.

14. Gills branched; clypeus with six dark spots, not always well defined; "eyebrow" without dark dot .. .. *latipes*, Mg.
Gills simple (at least in *S. aureum*); a dark dot in the anterior part of the "eyebrow" .. .. 15.

15. Clypeus with a median dark streak, more or less interrupted, and four other spots .. .. *aureum*, Fries.
Clypeus with eight distinct dark spots, including two transverse bars at each posterior corner .. .. *angustitarsis*, Ldst.

16. Antennae very long, blackish, 9–jointed; central tooth of mentum simple *subexcisum*, Edw.
Antennae short, pale at least basally, 3-jointed; central tooth of mentum strongly trifid .. .. *hirtipes*, Fries.

Pupae.

1 Prothoracic respiratory organs in the form of thick tubes, the main branches of which encircle the thorax at the nearly circular mouth of the cocoon .. .. *equinum* (L.) Edw.
Respiratory organs consisting of a number of slender filaments .. .. 2.

2. Respiratory filaments with numerous ultimate branches (50–60 or more); cocoon a loose shapeless network .. .. .. *hirtipes*, Fries.
Respiratory filaments with not more than thirteen ultimate branches; cocoons closely woven and shaped like the toe of a slipper, usually with semi-circular opening .. .. 3.

3. Respiratory filaments eight .. .. 4.
,, ,, six .. .. 9.
,, ,, four .. .. 14.
,, ,, thirteen .. .. .. *tredecimatum*, sp. n.

4. Cocoon with a long anterior dorsal projection: the upper two pairs of respiratory filaments with long vertical stalks .. .. .. *yerburyi*, sp. n.
Cocoon without anterior dorsal projection; respiratory filaments otherwise 5.

5. Filaments arranged in four shortly-stalked pairs .. .. 6.
Filaments not in pairs; all rather widely divergent close to the base, towards which 3 of them are noticeably thickened .. *subornatum*, sp. n.

6. Filaments much shorter than the pupa, all of equal thickness, the upper pair shorter than the others ; all four pairs with extremely short stalks ; cocoon with " windows " on each side in front
reptans, L., and var. *galeratum*, n.

Filaments about as long as the pupa ; upper pair slightly thicker but no shorter than the others ; cocoon without " windows " .. .. 7.

Fig. 4. Bases of prothoracic respiratory organs of *Simulium* pupae, side view, to show branching ; all × 35 : *a*, *S. ornatum* ; *b*, *S. ornatum*, var. ; *c*, *S. ornatum* var. *nitidifrons* ; *d*, *S. subornatum* ; *e*, *S. reptans* ; *f*, *S. morsitans* ; *g*, *S. variegatum* ; *h*, *S. monticola* ; *i*, *S. venustum* ; *j*, *S. tuberosum* ; *k*, *S. argyreatum* ; *l*, *S. latipes*; *m*, *S. aureum* ; *n*, *S. angustitarsis* ; *o*, *S. subexcisum* ; *p*, *S. yerburyi* ; *q*, *S. tredecimatum*.

7. The four lower filaments arising from a short common stalk at the base ; then with longer separate stalks, of which that of the lower pair is the longer
morsitans, Edw.

The three upper pairs of filaments separate from the lowest pair at the base 8.

8. The stalks of the two lower pairs of filaments usually longer than those of the two upper pairs .. .. *ornatum*, Mg.

All four pairs of filaments with short stalks of about equal length
ornatum var. *nitidifrons*, n.

9. Cocoon with a long anterior projection ; upper pair of filaments with a long vertical stalk ; lower filaments twice dichotomously branched from base *subexcisum*, Edw.
Cocoon without anterior dorsal projection ; filaments otherwise .. .. 10.
10. Filaments all widely divergent at the base, the uppermost one nearly vertical for a short distance .. .. *argyreatum*, Mg.
Filaments not widely divergent at base, all more or less in the same vertical plane, arranged in three shortly stalked pairs .. .. .. 11.
11. Filaments somewhat divergent, all about the same thickness ; cocoon all closely woven, as long as the pupa .. .. *venustum*, Say.
Filaments scarcely divergent, the lower pair somewhat thinner than the upper 12.
12. Cocoon short, usually not extending beyond the middle of the thorax ; filaments longer than the pupa, directed straight forwards .. *tuberosum*, Ldst.
Cocoon longer than the pupa ; filaments shorter .. .. 13.
13. Cocoon all closely woven ; upper pair of filaments considerably thicker than the lower .. .. *monticola*, Fried.
Cocoon loosely woven at the sides in front ; upper pair of filaments not quite so stout .. .. *variegatum*, Mg.
14. Filaments in two distinctly stalked pairs ; cocoon with anterior projection *latipes*, Mg.
Filaments all arising from a common base, or nearly so .. .. .. 15.
15. Filaments very stout at the base ; cocoon with anterior projection (short or long) .. .. *angustitarsis*, Ldst.
Filaments slender at the base ; cocoon without anterior projection *aureum*, Fries.

1. **S. ornatum,** Mg. (figs. 1*a*, 2*a*, 3*a*, 4*a* & *b*).

Larva.—General colour variable, usually greenish grey or dingy greenish-yellow, without special markings on the body. Head light yellowish-brown ; a median wedge-shaped dark mark near posterior margin of clypeus ; a spot on each side of this and sometimes a trace of a fourth anterior to the wedge-shaped mark ; usually also pairs of marks on each side at the posterior margin ; a dark stripe above and in front of the eyes. Antennae 5-jointed ; first joint usually a little shorter than second, which is often very imperfectly separated from the first and sometimes obscurely divided into two in the middle ; fourth longer than third ; last joint very short and conical. Mentum* with three teeth much larger than the others ; between the central tooth and each of the other large teeth are three small ones ; sides of mentum with four to six long hairs. Last abdominal segment without ventral papillae. Anal sucker with about 70 rows of hooks each containing 12–15 hooks about 10μ long. Anal gills 3, simple. Skin round anus beset with numerous minute scales dark in colour, and plainly visible under a magnification of 100, split apically into a number of spines (3–5).

* Often incorrectly spoken of as the labium.

Pupa.—Respiratory filaments about as long as the pupa, on each side 8 in number, arranged in 4 shortly stalked pairs, the stalks of the two ventral pairs usually the longest ; ventral pair slightly thinner than the others ; all the filaments more or less in one plane (the vertical). Cocoon tough, closely woven, about twice as long as its breadth in front ; height and breadth about equal ; anterior margin thickened, but without any forwardly-projecting piece in the middle ; no floor to the front half of the cocoon, which has its mouth widely open, and entirely covers the pupa.

Habitat.—Principally a river species, but occurs also in small streams, sometimes even those of a temporary nature. Where water-plants are present, the larvae and pupae attach themselves to the plants, and show a preference for those with long narrow leaves, such as *Sparganium* and water-grasses ; *Ranunculus* is less favoured, *Potamogeton* less still ; usually the larvae are found chiefly on the lower sides, the pupae chiefly on the upper sides of the leaves. In the smaller streams, where water-plants may be few or absent, the larvae and pupae are to be found on or under stones or on any suitable objects. The species is rarely met with in streams less than 4 feet in width.

Breeding Season.—This species appears to breed in suitable localities all the year round, almost regardless of the season. Pupae have been collected in every month of the year except January, from the middle of February until Christmas. On one occasion (19.ii.1917) fully developed pupae were collected immediately after a period of three weeks continuous frost ; these produced adults of both sexes a few days later. I took a newly emerged male in the open on 1st March 1919. There appear to be three main broods, in April, July and September.

Material collected.—Larvae and pupae have been collected as follows :—*Bucks* : R. Misbourne, near Denham, 10.ix.15. ; Burnham Beeches, iv. 1916, a few in stony stream with *S. latipes*. *Middlesex* : Harefield, 21.ix.15, in stony and weedy stream ; Pinner, 22–24.viii.15. *Surrey* : Beddington, near Mitcham, 31.vii.19 ; larvae in millions in river Wandle, pupae also numerous, but no adults seen ; a few pieces of leaf (totalling one yard in length) of *Sparganium simplex* carried approximately 500 pupae and 4,000 larvae, apparently all of this species. *Devon* : Larvae, and pupae numerous in many small streams in the valleys of the Dart and Teign, up to a height of 1,000 ft. ; also in the rivers Otter and Sid, and in small runnels on the sea-cliffs near Sidmouth, vi. 1920. *Hants* : New Forest, 1.v.1920, a few in small streams and in Beaulieu River, in company with large numbers of var. *nitidifrons* ; River Test (*M. E. Mosely*). *Herts.* : River Chess, near Chorley Wood, 30.viii.15 ; River Lea, near Hatfield, v.1916 and 12.iii.1917, on *Ranunculus* ; Pegsdon, 21.iv.16, on grass in small stream in " The Meg," larvae very large and very variable in colour ; Hitchin, 5 iii.15, under stones in stream 2–3 inches deep ; Radwell, 24.v.20, larvae of all sizes, very variable in colour, also some pupae, on stones in small rapid streams ; R. Ivel, near Baldock, vi.1917, on *Ranunculus*, *Sparganium*, etc. *Beds.* : Barton, 21.x.16, under stones. *Cambs.* : Bartlow, Hinxton, and Ashdon, 2.x.15, on grass and willow rootlets in small streams, none on stones in stream bed ; Wittlesford, 29.xii.15 and 3.vii.16, larvae on stones in small stream ; Stapleford, 28.iv.16, on grass at edge of small stream ; Shepreth, 19.ii.17 and 14.iv.17, on *Ranunculus* and *Oenanthe* in small stream ; R. Granta, near Hauxton, 7.iv.17, on sedge at edge of river ; Cambridge Botanical Gardens, 1.x.15, one pupa with

numerous *S. aureum* on tree-roots in streamlet. *Suffolk*: River Lark, near Mildenhall, 25.iv.16, in large numbers on various water-plants, chiefly *Ranunculus*. *Kent*: Bushyruff, Dover, 21.iii.1898 (*B. L. Hesse*). Wales: Anglesey, 19.ix.15, on stones in small stream across field (*C. B. Williams*). *Channels Is.*: Guernsey, Christmas 1910, all stages together (*K. G. Blair*). *Scotland*: near Edinburgh, 27.ix.15, on grass at edges of small stream flowing through fields; current flowing at rate of 6 yards in 10 seconds (*W. Evans*).

Variation.—In some localities the larvae of *S. ornatum* are fairly constant, in others they vary greatly in colour. Thus among 4,000 larvae from Mitcham, roughly examined, no variation was noticeable, while specimens from Pegsdon, Herts., and Harefield, Mx., varied in general colour from almost white to dark greenish, blackish or reddish; occasional specimens have dark brown markings as in *S. aureum*. The head markings are usually distinct, but may be obsolete; very dark specimens sometimes have the head almost all black. The larvae found in small streams seem to exhibit much more variation than those found in rivers, the greatest variation being shown by parasitised larvae. This may possibly indicate that *S. ornatum* is normally a river species, the variation being induced by the change of conditions to those found in small streams.

The pupae exhibit considerable variation in the length of the stalks of the pairs of respiratory filaments, but only in one specimen, out of hundreds examined, was any divergence seen in the number of filaments. This specimen had seven filaments on one side, eight on the other.

The adults vary in size, and as is the case in some other species, the spring broods seem to be larger than the summer ones, though this is not always very marked. The male varies to a remarkable extent in the silvery markings on the thorax, but only individually; a close study of the variation might however possibly indicate the existence of definite local or seasonal forms. One such form has been recognised in the New Forest, and is described below. Most males have the thoracic markings similar to those of the female, and no more conspicuous; some have conspicuous rounded silvery spots much as in the males of *S. reptans*, etc., while I have seen one or two beautifully marked examples with the whole of the margin of the mesonotum silvery, as well as the usual spots. All these are structurally typical; the only other character which I have noted to vary to any extent is the amount of black on the hind tibiae. The chief variation in the female is in the amount of white on the hind margins of the abdominal segments, which is sometimes very conspicuous, outlining three blackish areas on each segment. To this form Curtis' name *trifasciatum* will apply. It is evident that *S. ornatum* is at present a plastic species some derivatives of which have attained stability, while others are probably now in process of development and fixation. It is therefore not surprising that the American representative (*S. piscicidium*) should appear to be specifically distinct.

Blood-sucking.—Since my previous notes on this subject were published, I have had abundant evidence that this species is a blood-sucker, but it would appear not to bite except on warm and rather still days, chiefly in the afternoon sun. Mr. C. L. Walton sent me some specimens from Crosswood, Cardiganshire, which he took in August 1916 attacking horses about the nose and eyes. I have also taken *S. ornatum*

(Letchworth, 5.iv 18) on horses' bellies, and (Letchworth, 19.x.17) in numbers on calves' bellies, some containing blood. Besides this I have frequently taken females, sometimes apparently gorged, in cowhouses. Mr. W. Evans has noted the species biting his hand. I have also myself received bites from them on my nose, eyebrow and hand (25.iv.16, 19.x.17, 15.xi.17, 5–18 iv.19). The bites were not particularly painful and left no after-effects; most of them were inflicted while I was in a stooping position (*e.g.*, when gardening), and I frequently noticed that the flies were more in evidence then than while I was standing. Perhaps they mistake a man stooping for a horse or cow, which would seem to be their normal hosts.

References.—The early stages of this species have been described in more or less detail by a number of writers. The best figure of the pupa is that of Castellani and Chalmers (Manual of Tropical Medicine, Ed. iii. p. 812); the figure is not named specifically as that of *S. ornatum*, but is quite unmistakeable. A larva and pupa of *S. ornatum* have also been figured by Kollar (Sitzb. k. Akad. Wiss. Math.-Nat. Kl. i, pp. 92–107, pls. i–iii, 1848, under the name *S. sericeum*, Mg.); Grünberg (Die Süsswasserfauna Deutschlands, 2a, p. 107, figs. 128–130, 1910); Verdat (Naturw. Anz. allg. Schweiz. Ges. v, p. 65, 1822—as *S. sericea*); Liebe (Zeits. Naturw. 82, p. 345, 1910—larva only); Meinert (K. Danske Vid. Selsk. Skr. (6) iii, p. 373, 1886). The most recent writer is Friederichs (Zeits. f. angew. Entom. vi, pp. 61–83, 1919), who figures the male hypopygium and the pupal filaments of this species as *S. reptans*; with this use of the name *reptans* I cannot agree. It is not clear what species he would indicate as *S. ornatum*; possibly the one described below as *S. subornatum*.

1a. **S. ornatum** var. **nitidifrons,** nov. (fig. 4*c*).

Closely resembles *S. ornatum*, Mg., except that the frons of the female is shining and not dull; the mesonotum of the female appears distinctly more shining than in the typical form; and there is little or no white on the hind margins of the abdominal segments. The male does not differ perceptibly from that of *S ornatum*. Larva with the head markings rather more distinct. Pupa with eight branches to the respiratory organs, all about equal in diameter, arranged in four pairs, all almost sessile or with very short stalks of about equal length.

This form was abundant in the New Forest at the beginning of May 1920; larvae and pupae were collected on different water-plants in the Brockenhurst River, the Beaulieu River, and some small streams running into the latter. In the small streams it was the most abundant form Specimens of the normal form of *S. ornatum* were also reared from the same streams, but these were comparatively scarce. A few females were taken on the wing at Gidleigh Park, S. Devon, 2.vi.1920, but no larvae or pupae were found. Both sexes were reared from pupae found in company with *S. ornatum* near Shelve, Salop, vii.1920, on grass in a small stream. Dr. G. Enderlein has since sent me specimens of both sexes (identified as *S. reptans*) from Berlin; he also sent specimens, probably from the same batch, to Friederichs, who has described them as *S. reptans*.

This form bears a great resemblance to the Scotch and Welsh *S. monticola*; the latter is regarded as a distinct species, since it differs markedly from *S. ornatum* in the larvae, pupae and male hypopygium, whereas the New Forest form apparently does not.

2. **S. subornatum,** sp. n. (figs. 1*c*, 2*b*, 3*b*, 4*d*, 7*b*).

Adult.—Male : Thorax black, with fine golden pubescence and double silvery markings in front as in typical *S. ornatum*. Membranous area of pleura bare. Silvery markings on the sides of the abdomen not very conspicuous, but extending on to the 8th segment as well as the 6th and 7th (which is not the case in *S. ornatum*). Genitalia resembling those of *S ornatum*, but the stylus of the adminiculum (viewed from beneath) is much longer and narrower, more like *S. reptans*, but distinctly pubescent. Front tibiae silvery ; front tarsi thickened, the metatarsus about $5\frac{1}{2}$ times as long as broad. Middle tibiae yellow at the base Hind tibiae and metatarsi practically all black or dark brown, the latter moderately swollen.

Female : Face and frons dull grey. Thorax marked as in *S. ornatum*, but rather less distinctly ; pubescence of mesonotum finer. Abdomen with the first five segments dull, blackish, with white hind margins, the last three moderately shining, but rather less so than usual. Legs coloured practically as in *S. ornatum*, but rather less brightly ; middle and hind tibiae sometimes with traces of dark rings near the base, especially on the under-side ; claws simple. Other characters as in the male.

Larva.—Head markings similar to those of *S. morsitans*, but the H is not so dark and much less distinct. Abdomen without distinct banding. Antennae apparently 6-jointed, but the first four joints not very distinctly separated ; the first about as long as the second and third together, the second, third and fourth about equal in length. Mentum with 9 pointed teeth in the terminal row, the middle one and the one at each end larger. Sides of mentum with 5 or 6 long hairs. About 80 rows of hooks in the anal sucker, 12–15 hooks in each row. Skin round anus with a number of minute spines or scales, which are smaller, less numerous and less conspicuous than those of *S. ornatum*. No ventral tubercles on last segment. Anal gills retracted in all specimens examined.

Pupa.—Respiratory filaments 8 in number, the upper four rather widely divergent at the base, not arranged in pairs ; the uppermost one nearly vertical for some distance ; the upper three arise from a common base or a very short common stalk ; the next one is somewhat isolated ; the remaining four are in two pairs with very short stalks ; the three filaments on the inner side of the bunch are rather distinctly thickened towards the base. Cocoon differs from that of *S. ornatum* in being more loosely woven, with " windows " on each side in front.

Material collected.—I first recognised this species from two females sent me from Bayswater, Oxford, 15.vii.16 (*A. H. Hamm*) ; the same collector subsequently obtained a third at the same place, 8.vi.18. About 10 ♂ and 5 ♀ were received for determination in 1917 from Bulwell Hall Park, Notts., 21.vi.16. and 18.vii.16 (*J. W. Carr*). Some of these were presented to the British Museum, and I designate one of the males as type. I myself found a small swarm of the males hovering under a lime tree at Norton Bury Farm, Letchworth, 16.vi.17, and again at exactly the same spot on about the same date in 1918 ; in each case all the members of this swarm were this species, although *S. ornatum* was swarming under another tree close by ; I also obtained a single male by the river Severn at Shrewsbury, 24.vii.1920. A scrutiny of the series of *S. ornatum* in the British Museum revealed a single male of *S. subornatum* from Llangammarch Wells, Brecknock (*Lt.-Col. Yerbury*). Finally

Mr. M. E. Mosely has presented to the British Museum a number of pupae and a few larvae ; masses of the former were in a jar in Mr. Mosely's possession collected by the late F. M. Halford and labelled " Crickmere, 16.ix.1894 ; " Mr. Mosely also collected a few pupae himself in the River Test, Hants.

The species must be very similar to the North American *S. piscicidium,* but that is described as having yellow legs.

3. **S. variegatum,** Mg. (figs. 1*b*, 4*g*).

Larva.—General colour brownish or dark grey, without special markings on the body. Head usually dark at the sides above and below the eyes ; clypeal markings often faint, when present usually ill-defined, but arranged much as in *S. ornatum.* Antennae 5-jointed, the first as long as the next two or three together ; second sometimes indistinctly divided in the middle, twice as long as the third ; third shorter than the fourth. Mentum with 9 teeth in the terminal row, all slightly trilobed, the small lateral lobes pale ; middle tooth very large ; about 8 long hairs on each side almost in a straight line. Thoracic proleg with a pair of rather strongly chitinised plates above the ring of teeth. Last abdominal segment without ventral papillae. Anal sucker with about 85 rows, each with 12–15 hooks. Anal gills each with 8–10 rather long branches. Skin round anus with numerous minute dark scales, composed of short rows of spines (5–8 in each) ; the scales are much smaller and less numerous than those of *S. ornatum.*

Pupa.—Respiratory filaments about as long as the pupa, six in number, in three very shortly stalked pairs ; all the filaments more or less in the same plane ; upper pair rather thicker than the others. Cocoon very large, fully a third longer than the pupa, in texture close-woven behind and above, but with an open network on the sides towards the front ; this network often, but not invariably, continued round the front of the cocoon and enclosing the ends of the respiratory tubes, the cocoon then approaching the " boot "-shape of *S. equinum.*

Habitat.—Swift stony rivers and streams, both larvae and pupae on the upper surfaces of stones where the current is strong but smooth and the water not too deep.

Material collected.—Larvae and pupae were found in great abundance in early June 1920 in South Devon : in the River Dart through Holne Chase, the River Teign between Fingle Bridge and Christow, and the river Yeo near Ashburton, associated with *S. tuberosum* and *S. reptans* but in much larger numbers. A female specimen hatched from a pupa collected in 1912 at Ewbank Scar, Kirkby Stephen, Westmoreland (*C. B. Williams*), in company with larvae and pupae of *S. monticola,* Fried.

Blood-sucking.—In August 1916 Mr. C. L. Walton sent me females from Crosswood, Cardiganshire, which were taken in company with *S. ornatum* " attacking horses about nose and eyes and on belly."

Variation.—There seems to be great variation in the colour of the larval head, some being much darker than others.

Reference.—Friederichs has described the larva, pupa and adult of this species as *S. venefica,* sp. n.

4. **S. monticola,** Fried. (figs. 1*b*, 4*h*, 5*a*).

Adult.—Resembles *S. ornatum* in all respects except the following :—Membranous area of pleura bare ; front metatarsi about $6\frac{1}{2}$ times as long as broad ; male genital claspers broader, the external margin convex in the middle ; frons of female blackish, moderately shining ; abdomen of female entirely black. From *S. variegatum* the main if not the only differences are the shape of the male claspers, and the shining frons and dark femora of the female. This description agrees with that of *S. arcticum*, Mall., described from the female only from British Columbia, but without definite proof the two can hardly be considered the same.

Larva.—General colour dirty greenish-grey, with obscure darker abdominal banding (on first 5 segments). Head very dark at the sides, except just round the eye-spots ; clypeus dark on its posterior margin, in the middle with a short dark longitudinal mark in contact with the dark margin, and slightly anterior to this a pair of inconspicuous dark spots. Antennae as in *S. ornatum*. Mentum with 9 teeth in the terminal row, the central tooth and the one at each side rather larger than the others ; sides of mentum with 8–10 long hairs. No ventral papillae on last abdominal segment. Anal sucker with about 100 rows, each containing 15–18 hooks. Skin round anus as in *S. ornatum*. Gills each with about 8 branches.

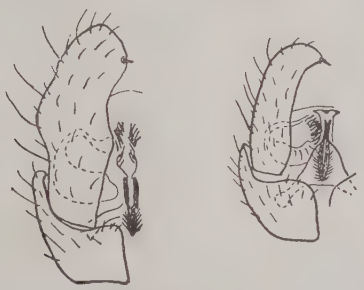

Fig. 5. Male hypopygium, seen from beneath :
a, *S. monticola* ; *b*, *S. subornatum*.

Pupa.—Respiratory filaments barely as long as the pupa, six in number, arranged in three pairs with very short stalks ; all the filaments in a vertical plane ; upper pair slightly swollen at the base and thicker than the other two pairs. Cocoon as in *S. ornatum*.

Habitat.—Moderately small swift streams, usually on rocks or stones ; both larvae and pupae usually on the upper or down-stream side. Sometimes present on stones covered with moss.

Breeding Season.—The first brood hatches in May, and there is certainly another brood, since a gravid female was taken near water in the middle of June, and full-grown larvae have been found in August.

Material collected.—The species was fairly common in most of the small burns in the north half of the Isle of Arran, 22.v.–7vi.19 ; there were few larvae left by the end of this time. A specimen was also taken in a wooded valley at Ffrith, Flintshire, 10.vi.19, and in the stream near by were numerous small larvae, possibly representing a second brood of this species. One or two specimens were reared from pupae

collected on stones in a rapid mountain stream at Kirkby Stephen, Westmoreland, 22.vii.1912 (*C. B. Williams*). Inverleithen, near Peebles, 7.viii.1910, adult males on the wing, larvae of various sizes and some pupae on stones and some on grass (*Dr. J. Rettie*, per *Dr. J. H. Ashworth*). Various streams in the neighbourhood of Pontesbury and Church Stretton, Salop, vii.1920.

Blood-sucking.—No definite evidence, but a few specimens (of both sexes) entered tent.

References.—Friederichs, in the paper cited in the introduction (Oct. 1920), describes this species from the Harz Mountains. I have distributed it to various correspondents under the MS. name *obreptans*.

5. **S. reptans,** L. (figs. 1*d*, 2*c*, 4*e*).

Larva.—General colour greyish. Head with a single dark spot of varying size and shape in the middle of the posterior margin of the clypeus ; no dark mark above eye-spots. Abdomen with conspicuous dark greenish bands on all the segments dorsally, those on 6–8 nearly confluent. No ventral papillae on last segment. Gills each with 4 to 5 short branches. Skin round anus with numerous minute almost colourless simple scales. Teeth of mentum rather blunt, the nine in the terminal row all slightly trifid, the small lateral lobes pale. Antenna 5-jointed, gradually tapering to the end of the 3rd ; first scarcely as long as the next two together, second nearly twice as long as the third. About 75 rows of hooks in the anal sucker, 12–15 hooks in each row.

Pupa.—Respiratory filaments much shorter than the pupa, 8 in number on each side, spreading but little from the vertical plane ; arranged in 4 very shortly stalked pairs ; uppermost pair rather shorter than the others ; all the stalks equal in length and all the filaments of equal diameter, slightly and evenly tapering towards the tips. Cocoon as in *S. ornatum*, except that on each side towards the front there is a rather large open space, usually crossed horizontally by one or two bands of silk.

Habitat.—Swift shady rivers in mountainous regions, but not at high altitudes. Where water-plants (such as *Ceratophyllum*) are present the larvae and pupae occur on them in some numbers, but are most typically found on the flat upper surfaces of large stones where the current is strongest, and particularly in those places where the flow is smooth and even and where there is no great depth of water. No larvae were found in the bare valleys above the tree-line, and very few in places where the rocks were much covered with moss.

Breeding season.—The first brood of the year does not appear until the end of May or the beginning of June. I have had no opportunity of ascertaining whether there is a second brood, nor what is the method of over-wintering.

Material collected.—The species was abundant in Machrie Water and in the burn flowing through Brodick Woods, Arran, v–vi.1919, in company with *S. tuberosum*. It did not occur in the smaller burns on the island. Also found in Devonshire, in small numbers in the Upper Teign and in the Yeo near Ashburton, and more numerous in the Otter at Tipton St. John and in the Sid at Sidmouth, in the former case in company with large numbers of *S. variegatum*, and in the latter with *S. ornatum* and other species, 1–18.vi.1920. A single male was taken on the wing near Church Stretton, Salop, 21.vii.1920.

Variation.—None noticed, except, as already mentioned, the size of the single dark spot on the head of the larva.

Blood-sucking.—I have little to add to my previous notes except that up to the time I left Arran (5.vi.19) I was not attacked, and no females were even seen on the wing in Devonshire (up till 17th June). Probably the insect requires to be on the wing for some time before proceeding to its blood meal. Mr. P. H. Grimshaw writes "The specimens from Rannoch repeatedly flew at my face, in fact chiefly at my eyelids, and proved very irritating. They did not actually bite, but possibly would have done if I had given them the chance."

5a. **S. reptans** var. **galeratum,** nov. (fig. 1*e*).

Adults.—Not positively identified, but probably identical with *S. reptans.*

Larva.—General colour light greenish, with darker but not very conspicuous transverse bands on the abdomen. Head yellowish, clypeus with a black spot in the middle of the posterior margin, connected anteriorly with a large roundish black mark which occupies almost the entire breadth of the clypeus ; its edges are not very sharply defined and it has a small anterior emargination. A dark rim above and behind the eye-spots, sometimes entirely surrounding them. Antennae apparently only 4-jointed, the first joint longer than the remaining three together, second about equal to the third (the division between what are usually the first two joints seems to have disappeared). Mentum as in *S. reptans.* The pigment-spots within the sides of the sixth and seventh abdominal segments are darker and more conspicuous than usual. No ventral papillae on last abdominal segment. Gills either quite simple or with one or two (rarely three) short branches. Skin round anus with a few minute colourless scales. About 65–70 rows of hooks in the anal sucker, 10–15 hooks in each row.

Pupa.—Apparently indistinguishable from that of *S. reptans.* The respiratory filaments as dissected from the fully developed larva are as in *S. reptans*, and the single pupa collected that can with certainty be referred to this species (owing to its still retaining the larval head-capsule) showed no obvious difference either in the pupa itself or in the structure of the cocoon from *S. reptans.* This pupa was unfortunately not isolated, and the adult issuing was lost among a number of *S. reptans.*

Material collected.—Larvae were abundant on stones and water-plants (*Sparganium*, etc.) in the river Otter at Tipton St. John, S. Devon, 14.vi.1920, in company with many *S. ornatum* and *S. reptans*, and a few *S. equinum* and *S. aureum.*

Although this species was the most abundant in the larval state, even more so than *S. ornatum*, no adults were reared from pupae which could be correlated with these larvae, all the specimens obtained being either *S. reptans* (in the largest numbers), *S. ornatum* or *S. equinum.* This would seem to suggest that the form under consideration may be only a local form of *S. reptans* which has developed distinct characteristics in the larval state only ; but against this it must be stated that a small number of larvae were obtained at the same time and place which agreed in every respect with the Scotch form of *S. reptans* as described above. Moreover, in the river Teign, and even in the Sid, two or three miles distant, only normal

larvae of *S. reptans* could be found. Since, however, the only structural difference between this form and *S. reptans* is in the simple or less branched gills, it seems on the whole most probable that it is a variety of *reptans*, and I have so regarded it pending further investigation. The name has reference to the cap-like black patch on the head of the larva, a most striking feature.

6. **S. morsitans,** Edw. (figs. 1*f*, 4*f*).

Adult.—Both sexes have now been obtained by breeding. The female is very difficult to distinguish from that of *venustum* ; there seems to be no constant difference in the colour of the base of the abdomen, as I previously thought, but this species may perhaps be separated (in the female sex) by the greater amount of yellow on the middle tibiae. The only clear distinction in the adult, however, appears to be in the shape of the male claspers.

Larva.—General colour rather pale yellowish-green without distinct darker markings. Head yellowish, the clypeus with a conspicuous and rather sharply defined black mark in the form of an **H**. Antennae 4-jointed, the second joint a little longer than the first, third scarcely as long as second, fourth minute. Mentum with 9 teeth in the terminal row, the middle one long, the one at each end very broad, intermediate ones indistinctly trilobed ; four or five long hairs at the sides. Last abdominal segment without ventral papillae. Anal sucker with 65–70 rows of hooks, about 15–20 in each row. Skin round anus bare. Gills with 5 or 6 branches all approximately equal in size.

Pupa.—Respiratory filaments 8, about as long as the pupa, in four pairs, the two lower pairs slightly thinner than the upper, and arising from a short common stalk ; each of the four pairs also with its own stalk, that of the lowest pair distinctly, often much, longer than the others ; all the filaments in the vertical plane, not at all swollen towards the base. Cocoon as in *S. ornatum.*

Habitat.—Weedy rivers of moderate current in company with *S. ornatum*, *S. venustum* and other species. Not found as yet in small streams.

Breeding season.—There may be two broods in the year, as adults have been obtained in May and July, but the May brood is certainly the more numerous.

Material collected.—Two males were reared from pupae found in the river Granta at Hauxton, Camb., 5.vii.15, on *Scirpus* in company with large numbers of *S. equinum* and *S. argyreatum.* A fair number of larvae and pupae were found on grass and *Ranunculus* at the edge of the Lymington River, near Brockenhurst Bridge, New Forest, 2.v. 20.

7. **S. venustum,** Say (*austeni*, Edw.) (figs. 1*g*, 4*i*).

Adult female.—A number of females have been obtained by rearing ; they appear to differ from those of *S. morsitans* as shown in the table. I have failed to discover a better distinction.

Larva.—General colour bright green, the abdomen with rather indistinct bands of darker green. Head light in colour, with a pair of somewhat oval dark spots at some distance from the neck, lying close together, connected at or near their anterior ends by a transverse bar ; usually also a dark area along the posterior margin of the clypeus. (The areas which in most species are dark are here pale, with dark areas

more or less surrounding them.) Antennae and mentum as in *S. morsitans*, the mentum however with a broader black terminal portion. Anal sucker and gills as in *S. morsitans*. Skin round anus with some very minute scales, inconspicuous even under a magnification of 300.

Pupa.—Respiratory filaments about as long as the pupa, six in number, arranged in three distinctly stalked pairs, the stalk of the uppermost pair nearly vertical, slightly longer and thinner than that of the middle pair. All the filaments in the vertical plane at the base, slightly and evenly tapering towards the tips, bases not at all swollen. Cocoon as in *S. ornatum*.

Habitat.—Weedy rivers of moderate current.

Breeding Season.—The first brood appears at the end of April; we have yet no clear evidence as to whether there is a second. A very few adults have been captured in August, and Miss F. Collins collected eggs in May 1911 at a spot where *S. venustum* was abundant, but these may have belonged to some other species.

Material collected.—Larvae and pupae: New Forest, Hants., 1–3.v.1920; numerous on grass and *Ranunculus* in Lymington River at Brockenhurst Bridge, also a few specimens in small streams running into Beaulieu River. Pupae: West Moors, Dorset, v.1911 (*Miss F. Collins*); R. Granta near Cambridge, 28.iv.16, on *Ranunculus* with *S. equinum*; Stapleford, Cambs., 28.iv.16, one on grass at edge of stream, with *S. ornatum*. Adults, additional localities: Horley, Surrey, v.15 (*G. A. H. Bedford*); Oxford district, v.16 (*A. H. Hamm*); Letchworth district, v.17, v.18, v. 19, often at considerable distances from the nearest possible breeding places, some males as far as two miles; New Forest, 1–3.v.20, numerous in various localities, males swarming, females entering tent; Shrewsbury, 21.vii.20, one female.

References.—The pupa described and figured by Otto Fabricius (Schriften der Berl. Ges. Nat. Freunde, v, 1784, pp. 254–259, pl. iv) as that of *S. sericea*, Linn., may possibly be this species. Fabricius found the pupae in July on *Potamogeton lucens* in Norwegian rivers.

A pupa figured (though not named) by Vogler (Mitt. Schweiz. Ent. Ges. vii, p. 279, 1886) is almost certainly *S. austeni*. Vogler found it in company with *S. equinum* (which he also figures) on *Ceratophyllum* and other water-plants in the river Rhine.

S. austeni is so extremely closely allied in all stages to the North American *S. venustum*, Say, as figured by Malloch and Pomeroy, that it cannot be ranked as more than a local race. I have compared the genitalia of British specimens with those of a specimen from Spartanburg, S.C. (*A. W. Pomeroy*) and can find scarcely any difference. Both males and females are otherwise indistinguishable, and there is no structural difference in the larvae or pupae. Even the head markings of the larva are of the same type, though most of the British specimens examined had the dark markings developed to a somewhat less extent; examples could probably be found however to match Pomeroy's figure exactly. Though structurally identical, the two races seem to have developed biological differences. Pomeroy states that in America *S. venustum* female is abundant from early spring to late autumn in the ears of horses, and that there are three or four broods in the year. In this country, as mentioned above, there seems to be normally only a single brood, while no examples have so far been found in horses' ears.

8. **S. tuberosum,** Lundstr. (fig. 4*j*).

Larva.—General colour dingy greyish or greenish grey ; head pale above, without dark markings ; abdomen with dark dorsal bands on the first five segments, the first two sometimes interrupted ; segments 6–8 all dark above. Antennae as in *S. reptans*. Mentum with 9 teeth in the terminal row, all simple, the middle one and the one at each end considerably larger than the others. Anal sucker with about 80 rows, each containing 12–15 hooks. Skin round anus bare. No ventral papillae on last segment. Gills each with from 6 to 8 branches.

Pupa.—Respiratory filaments 6, in three pairs, each pair distinctly stalked ; filaments much longer than the pupa and all directed nearly straight forwards ; the two ventral pairs appear to be given off from the main stem which terminates in the dorsal pair. Cocoon constructed as in *S. ornatum*, but smaller, both actually and relatively to the pupa, rarely extending beyond the middle of the thorax.

Habitat.—With *S. reptans*.

Breeding Season.—As in *S. reptans*.

Material collected.—The species was very numerous in Machrie Water and Brodick Wood Burn, Arran, v–vi.1919, in the latter much more abundant than *S. reptans*, though in the former *S. reptans* predominated to some extent. Also found in Devonshire, in small numbers in the river Dart at Holne Chase, and the river Teign below Fingle Bridge. The occurrence of this species and of *S. reptans* so far south is of interest, and was somewhat unexpected, but their association with hilly country is confirmed.

Variation.—None noticed, except to a slight extent in the size of the cocoon.

Bloodsucking.—No further data available.

9. **S. argyreatum,** (Mg.) Lundstr. (figs. 1*h*, 4*k*).

Larva.—General colour rather reddish grey. Back of head with four distinct rather elongate dark spots, the posterior one darker than the others, usually all enclosed in a dark cloud ; dark eyebrow present, but without any included darker dot. Abdomen with a conspicuous dark band on each segment. Antennae as in *S. reptans*. Mentum with 11 teeth in the terminal row, the middle one and the second from each end somewhat larger than the others. Anal sucker with about 80 rows, each containing 14–18 hooks. Skin round anus with a very few simple scales. Very small ventral papillae on last segment. Gills simple.

Pupa.—Respiratory filaments 6, about as long as the pupa, not arranged definitely in pairs, but all arising almost from a common base and spreading out considerably at the base in all directions ; the uppermost one a little thicker than the other five, its basal part approaching the vertical. Cocoon as in *S. ornatum*.

Habitat.—Weedy rivers with only a moderate current, usually associated with *S. ornatum* or *S. equinum* or with both these species. The larvae and pupae seem particularly fond of the leaves and stems of *Scirpus lacustris*, and of other plants with ribbon-like leaves, though they are by no means confined to these plants. The larvae predominate on the lower sides, the pupae on the upper sides of the leaves.

Breeding Season.—The larvae of the first brood become full-fed about the end of March, the flies appearing early in April, or possibly in March in some cases. Development must be rapid after this as second-brood specimens have been taken as early as the 25th April. On the other hand, first brood specimens have been taken as late as 9th May (*A. H. Hamm*). The main second brood, however, appears at the end of June, and seems to be the most numerous in individuals. There is certainly also a third and perhaps a fourth brood. I have so far been unable to discover the species in any stage in the winter. The oviposition has not been observed.

Material collected.—Larvae and pupae have been collected as follows :—*Cambs.* : River Granta at Hauxton, 5.vii. 15, on *Scirpus lacustris* ; 7.iv.17, on sedge at river's edge ; Shelford, i.vii.15. *Suffolk* : River Lark, near Mildenhall, 30.ix.15 and 25.iv.16, on *Ranunculus* and *Sparganium*. *Herts.* : River Ivel near Radwell. *Beds.* : Cardington Mill, 28.vi.15, on leaves of *Scirpus* and *Sparganium*. *Hants.* : River Test (*M. E. Mosely*). Mr. H. Garnett has also sent me specimens taken near Evesham flying in clouds over the River Avon, in which thousands of *Simulium* larvae were living.

Variation.—None has been detected in the larvae or pupae, but for the reasons stated in the introduction I have come to the conclusion that these are two well-marked seasonal forms of the adult, the first representing the spring brood, the second the subsequent broods. These can be distinguished as follows :—

Spring form (var. *sericatum*)* : Length of body 3–3·5 mm. Markings of male thorax not silvery, only dull greyish ; the two patches towards the front of the mesonotum are produced backwards as two rather narrow lines as far as the scutellum and the thorax might therefore be described as greyish with three broad black stripes. Female thorax only moderately shining ; when viewed from in front it shows fairly evident traces of two longitudinal greyish stripes. Front coxae of female black, grey-dusted.

Summer and autumn form (*argyreatum*) : Length of body 2–2·5 mm. Markings of male thorax silvery, especially when viewed from in front, consisting of a pair of more or less triangular patches, with their apices directed backwards. Female thorax rather brightly shining, without a trace of longitudinal stripes. Front coxae of female reddish, grey-dusted.

Blood-sucking.—Further experience only confirms the view that this species is a habitual blood-sucker. At Mildenhall, 25.iv.16, it was in great numbers and very troublesome to a distance of quite half a mile from its breeding place, biting both head and hands. Though, to judge from the relative abundance of pupae, this species was much less numerous than *S. ornatum*, by far the greater proportion of the bites were inflicted by it, and I also noticed that *S. argyreatum* commenced its attacks much earlier than did *S. ornatum*. Other records were obtained in the Letchworth district, e.g., 18.iv.1919, bites on hand and ear. These were chiefly if not all of the spring form, but Mr. A. H. Hamm has provided me with several records of the summer form biting in the Oxford district (23.ix.16, 6.vi.17).

* M. Séguy notes in regard to Meigen's type of *S. sericatum*, " Détruit, le débris qui reste répond bien a votre description ♀." He also states that the types of *S. argyreatum* and some others " répondent bien à vos tableaux."

References.—It is possible that *S. argenteostriata*, Strobl, as described by Corti (Atti Soc. Ital. Sci. Nat. liii., p. 192, and liv, p. 223, 1914–16) is the spring form of this species, but I have not seen Italian specimens. The pupal filaments have recently been figured by Friederichs (Zeitschr. f. angew. Ent. vi, p. 61, 1919).

10. **S. equinum** (L.) Edw. (figs. 1*i*, 2*d*, 3*c*, 6*a*, *b* & *c*).

Larva.—General colour rather bright green, body-markings darker green, but not conspicuous. Head with 6 distinct dark spots, 4 arranged as usual in the form of a cross, the other two being on the posterior margin of the clypeus. No dark stripe above the eyes. Antennae rather slender, 4-jointed ; the second joint nearly twice as long as the first or the third, which are about equal in length ; fourth minute. Mentum with 9 simple teeth in the terminal row, the central one and the one at each end much larger than the others. About 100 rows in the anal sucker, each with 20–25 hooks. No ventral papillae on last segment. Skin round anus bare. Anal gills simple.

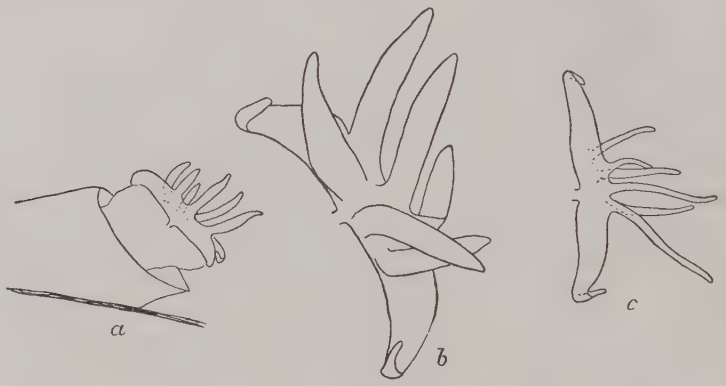

Fig. 6. *Simulium equinum*, L. : *a*, pupal skin of a hatched specimen projecting from mouth of cocoon, × 10 ; *b*, respiratory organ of left side, seen from the right, × 25 ; *c*, variety of pupal respiratory organ, × 25, from a specimen found in the River Test by Mr. M. E. Mosely.

Pupa.—Respiratory organs consisting of thick tubes instead of long thin filaments. Close to the body of the pupa the organ divides into a dorsal and a ventral section, which are entirely in contact with the pupa on the one side and with the cocoon on the other. The tips of these dorsal and ventral sections are abruptly narrowed and slightly overlap those of their fellows of the opposite side. From the dorsal section there project forwards five rather short and stout branches, two on the outer side and three on the inner ; the ventral section gives off a single branch near its base ; these branches are not more than one-third of the length of the pupa. Including the tips of the main sections, there are thus eight branches in all. The chitin forming the tubes is very thin and usually bears minute spines scattered over its whole surface, visible as dark dots under a magnification of 100. Cocoon closely woven, somewhat boot-shaped, that is to say, the anterior part of the floor is raised at an angle with the remainder, the opening being practically circular ; anterior margin not thickened.

Habitat.—Weedy rivers with only a moderate current, usually associated with *S. argyreatum* and sometimes also *S. ornatum*, on various water-plants, to a depth of 6–9 inches, the larvae mainly on the lower or down-stream side of the leaves, the pupae mainly on the upper or up-stream side.

Breeding Season.—There are probably three main broods in the year, in March or April, July and September. No evidence has so far been obtainable as to the method of over-wintering, the earliest date on which larvae or pupae have been collected being 7th April, and the latest 10th September. Females, however, have been captured on the wing as early as February, and specimens of both sexes, obviously newly hatched, at the beginning of April.

Oviposition.—Mr. H. Britten has given (Ent. Mo. Mag. May 1915) some interesting notes on the oviposition of this species, and in May 1919 I was able to confirm his observations, watching the females enter the water for the purpose of laying their eggs. In this case the eggs were deposited on a dead willow branch which was lodged in the river Ivel near Sandy, Beds. The insects chose a spot which was entirely sheltered from the current in order to enter the water, walked in to a depth of several inches and laid their eggs on the lower side of the branch. As Newstead noticed in the case of *S. ornatum*, the wings were wrapped round the abdomen and confined a layer of air between them and the body. Oviposition completed, the insect walked to the down-stream side of the branch, let go its hold and rose to the surface in its bubble of air. Some specimens took to flight the moment they reached the surface, others floated on the water for a few seconds before being able to rise.

The eggs of *S. equinum* are not, like those of other species, enclosed in a hard gummy matrix, but in soft jelly like those of many CHIRONOMIDAE. They are however placed close together in a single layer.

Material collected.—Larvae and pupae have been obtained as follows :—*Bucks.* : R. Misbourne, near Denham, 10.ix.15 ; R. Colne, near Denham, and stream in Denham village, 26.viii.15, larvae of all sizes and pupae, chiefly on water-plants, a few on stones. *Herts.* : R. Chess, near Chorley Wood, 30. viii. 15, immature larvae ; River Lea at Hatfield, v.1916, on *Ranunculus* ; River Ivel at Radwell, various dates. *Cambs.* : River Granta at Hauxton, 5.vii.15, in immense numbers on *Scirpus* and *Potamogeton* ; also at Shelford, 1.vii.15 and v. 17, and Grantchester, 28.iv.16, on *Ranunculus* ; Hauxton, 7.iv.17, numerous pupae and some larvae in one patch only on sedge at side of river. *Suffolk* : River Lark, near Mildenhall, 25.iv.16, on *Ranunculus*, etc. ; numerous ♂♂ hovering in shade, but scarcely any ♀♀ seen on the wing, and none bit. *Hants.* : Bournemouth (*Dr. J. H. Ashworth*) ; River Test (*M. E. Mosely*). *Devonshire* : In small numbers in the River Otter at Tipton St. John and in the River Sid at Sidmouth, mostly on water-plants, a few on stones.

Variation.—None noticed in larvae. In the pupae the minute spines on the surface of the respiratory organs are sometimes absent. The adults of the spring brood appear to be decidedly larger than those of the subsequent broods ; there is also much variation in the colour of the thoracic and abdominal pubescence of the females, some specimens being much more golden than others ; possibly the spring brood might be distinguishable by being on the average less brightly coloured. The

dark stripes on the thorax of the female vary in width and distinctness, being hardly distinguishable in very dark specimens; the legs are much darker in some specimens than in others.

Examples from the Mediterranean region (*e.g.*, those recorded in my previous paper from Fez) differ in the paler colour of the pubescence of the thorax in the female. Some pupae of this form collected by Capt. J. Waterston in Macedonia differ from the British forms in having the six minor branches of the respiratory organs longer, more slender, and closer together at the base. The larvae are alike. A single half-developed female pupa of this form has recently been given me by Mr. M. E. Mosely, who took it in company with normal pupae in the River Test, Hants., ix.1920 (see fig. 6,*c*).

Blood-sucking.—Ample confirmation has been obtained of the statement that this species normally feeds in horses' ears, and it would seem that it is the only blood-sucking fly in Britain which does so; its activities must therefore be only too well known to agriculturists. Numbers of females were taken from ears of barge-horses on the canal near Uxbridge, 21.viii.16, no other species being seen. On 5th April 1918 (as well as on other occasions) many were found in ears of farm horses at Letchworth, from 30 to 40 in each ear, and though all were carefully examined no other species was found. Some of these specimens were so gorged that the blood was oozing from the end of the abdomen; contrary to Pomeroy's observation regarding *S. venustum* in America, they were not at all readily disturbed. On another occasion they were found to be much more numerous still, covering the inside of the ear like velvet, with their bodies closely packed, at right angles to the surface of the ear, and holding on only by their mouth-parts and front legs. Again at Digswell, Herts., 9.vii.19, swarms of females of this species (and no other) were found flying round horses' ears; the animals were much troubled by them and endeavoured to escape by standing in the river with their heads under the arch of a bridge, against which they could flick their ears. I have never found this species biting any other part of a horse.

On one occasion (Letchworth, 19.x.17) a few specimens were found in calves' ears, while at the same time there were numerous *S. ornatum* ♀ on the bellies of the animals. I think, however, there is no doubt that the horse is the main host, as I have several times searched for them in vain in the ears of cows.

Mr. A. H. Hamm has supplied me with one or two additional records of the species biting the human subject; I have not experienced the bite myself, though a few of the insects not infrequently fly round one. It is of some interest to note that, as might be anticipated, they fly round the top of the head and often settle on a person's hat.

References.—The remarkable pupa of *S. equinum* has been described and figured by Vogler (Mitt. Schweiz. Ent. Ges. vii, p. 278, 1886), who did not however recognise the species he was describing. There are two other described pupae which bear an approximate resemblance to *S. equinum*. These are *S. botulibranchium*, Lutz, from South America and *S. damnosum*, Theo., from tropical Africa—the latter recently described by Pomeroy (Ann. Mag. Nat. Hist. (9) v, p. 80, 1920). The adult of Lutz's species is unknown; that of *S. damnosum* has a much greater resemblance

to *S. reptans* than to *S. equinum* in general characters, though in the male genitalia there is certainly some resemblance between *S. damnosum* and *S. equinum*. From these and similar facts we may conclude that pupal characters may be useful as indicating unexpected relationships, but can hardly be adopted for defining subgenera.

11. **S. latipes,** Mg. (figs. 1*j*, 2*e*, 3*d*, 4*l*).

Adult.—Rearing experiments have shown that the female I previously described as *S. latipes* was really that of *S. angustitarsis*; *S. latipes* ♀ is easily recognisable by the characters given in the key. The pink abdomen is nearly always very noticeable in life.

Larva.—General colour dirty greyish or brownish, with indefinite darker markings. Head dark, with slightly darker markings arranged in the usual cross-shaped manner, but very indistinct. Antennae extremely slender, first joint about six times as long as broad, somewhat narrowed towards the tip, second nearly twice as long but not half as broad, third half as long and half as broad as the second, fourth minute. Mentum with 11 teeth in the terminal row, the central one and the second from each end much larger than the others. On the ventral side of the last abdominal segment are two conical papillae, nearly as long as the gills but with broad bases. Anal sucker of about 80 rows, each containing 12–15 hooks. Skin round anus bare. Anal gills each with about 8 branches.

Pupa.—Respiratory filaments much longer than the pupa, four in number, arranged in two shortly but distinctly stalked pairs. All the filaments of about equal thickness, slightly and evenly tapering to the tips, and arranged in one plane (the vertical). Cocoon tough, closely-woven, about 1·5 times as long as broad, usually broader in the middle than in front, height in front barely equal to the breadth; front margin thickened and provided with a rather long median projection. There is a definite inner layer surrounding the abdomen of the pupa but not attached to the surface of the stone; no floor to anterior part of cocoon; mouth widely open.

Habitat.—Small temporary streams and rills, especially those with stony bottoms, and perhaps most frequently in or near woods; only very exceptionally in rivers or fair-sized streams. The larvae congregate mainly on the undersides of stones, or if these are not available, under dead leaves and twigs; the pupae are more usually on the upper surface, and never deeper than an inch or two.

Breeding Season.—The flies appear early in April, and there seems to be normally only one brood in the year; the rate of development of the larvae seems to be very irregular, and this will probably account for the presence of pupae as late as the middle of June. In favourable circumstances however it is not improbable that there may be a small second brood.

Egg-laying takes place in the early summer, and though I have never found the eggs, I have watched gravid females hovering over little sheltered spots of the rills and every now and then dropping suddenly almost to the surface of the water and rising again as suddenly. I could not ascertain whether eggs were being dropped, but if they were, the species has a very different method of oviposition from that of others of the genus.

Many of the streamlets in which *S. latipes* abounds are completely dry for the greater part of the summer, and though they may fill up during the autumn rains, I have not yet detected the presence of young larvae before about Christmas. It will be of considerable interest to discover exactly what happens to the insect during the dry season. I consider it most probable that it exists in the egg-stage, and that the egg-burster is a modification similar to that found in mosquitos of the *Aëdes* group, which are capable of sustaining prolonged desiccation in the egg stage.

Material collected.—Larvae and pupae occurred in abundance in most of the streamlets round Harrow, Pinner, Northwood, Ruislip and Stanmore, Middlesex, in the spring of 1915 and 1916. The earliest pupae were found about the end of March. Hatch End, Middlesex, 7.viii.15, larvae and pupae in stream which had been dry from middle of May to beginning of July ; larvae not nearly so common as in the spring. Streamlets in and near Knebworth Wood, Herts., half-grown larvae 4.iii.17, larvae and pupae on stones and grass, 11.iv.17, numerous under stones, 10.v.20. Norton Common, Letchworth, Herts., small larvae xii. 1916, somewhat larger ii. 1917, pupae and some larvae 17.iv.17, a few larvae left 7.vi.17 ; many small larvae, chiefly second stage, but a few first and third stage, 21.xii.19 ; the stream was quite dry from June till early November 1919 ; larvae of all stages i–vi, but chiefly v, 29.ii.20. Burnham Beeches, Bucks, iv.1916. River Lea, near Hatfield, Herts., v.1916, two pupae on *Ranunculus* in company with numerous *S. ornatum* and *S. equinum* ; one of these had the anterior projection of the cocoon forked, perhaps owing to its unusual environment. Streamlets on flanks of Goat Fell, Isle of Arran, v.1919, up to a height of 1,000 ft. Inverleithen, near Peebles, 7.viii.1910, larvae of various sizes on grass (*Dr. J. Rettie*, per *Dr. J. H. Ashworth*). New Forest, Hants., 1.v.1920, larvae, mostly full-grown, and pupae, on grass and *Ranunculus* in small streams running into Beaulieu River, also in the Beaulieu River itself about a mile above Beaulieu. River Test, Hants. (*M. E. Mosely*). In numerous small stony streamlets in the valleys of the Dart and Teign, S. Devon ; also a few in the River Teign below Fingle Bridge, vi.1920.

Variation.—There seems to be but little variation in the adult or pupa, except to a slight extent in size and in the length of the stalks of the pairs of pupal filaments and the length of the anterior projection of the cocoon. The larvae also are fairly constant in any one locality, though the head markings vary in intensity, and the young larvae have usually darker heads than the larger ones, with less defined markings. The New Forest larvae had rather distinct reddish-brown bands on the abdomen, much as in *S. aureum* ; these markings are usually hardly perceptible in Hertfordshire specimens.

Blood-sucking.—For a long time I considered that this species was not a blood-sucker, and in fact it was long before I captured a female on the wing, in spite of searching for them near the places where the larvae were abundant. Swarms of males were found hovering in the shelter of hedges, but at first no females were seen. However in the Isle of Arran, at the end of May 1919, females were very numerous in Sannox Wood and by some of the wooded burns, flying round us in swarms, and so far as could be ascertained all the bites received were inflicted by this species ; it could easily be recognised by the naked eye on account of the pink abdomen.

References.—The larva and pupa have been figured (rather inaccurately) by Lt.-Col. A. Alcock in *Entomology for Medical Officers*, 1911, p. 126. There is also a very good and detailed description, with figures, of the tracheal system of both larva and pupa by Taylor (Trans. Ent. Soc. London, 1902, p. 701). Neither of these authors however had named the species. The species in which Weismann (Abh. Senckenberg. Natf. Ges. iv, p. 249, 1862) studied the development of the tracheal system would also appear from his figures to be *S. latipes*, not *S. sericeum*. Friederichs (Zeitschr. f. angew. Ent., vi, p. 61, 1919) sinks *latipes*, Mg., as a synonym of *maculatum*, Mg., but this seems to me to be without justification.

12. **S. angustitarsis,** Lundstr.* (figs. 1*l*, 4*n*).

Larva.—Head with eight dark spots above, four arranged in the usual cross-like formation, the other four in two transverse pairs near the posterior margin; a dark stripe over the eyes, including a small blackish dot. Antennae much as in *S. aureum*, the second and third joints a little longer. Mentum as in *S. aureum*. The other characters cannot be given, as the only two larvae which have yet been found had partly transformed to pupae. The head-markings should be unmistakeable, though similar to those of *S. aureum*.

Pupa.—Respiratory filaments four in number, longer than the pupa, all arising practically from the same point, widely divergent at the base, the upper two considerably swollen basally. Cocoon as in *S. latipes*, except that the anterior projection is usually very short.

Habitat.—Weedy rivers with only a moderate current, in company with other species, such as *S. ornatum*, *S. argyreatum* and *S. equinum*, but always in much smaller numbers, and might usually be regarded as rather scarce. Very rarely in small streams.

Breeding Season.—Nothing definite can be stated except that pupae have been collected from April to July and in September, while females have been taken on the wing in November.

Material collected.—Pupae have been obtained as follows:—*Cambs.*: Stapleford, 28.iv.16, on grass; 1.vii.15, on *Sparganium*. *Herts.*; River Lea near Hatfield, v.1916; River Ivel near Radwell, 16.vi.17, on *Ranunculus*. *Suffolk*: River Lark, near Mildenhall, 30.ix.15, and 25.iv.16, on *Sparganium*. *Hants.*: River Test (*M. E. Mosely*). *Wales*: Anglesey, 19.ix.15, one pupa on stone in small stream across field (*C. B. Williams*).

Additional localities for the adults are:—Timworth, Suffolk (*Lt.-Col. Nurse*); Wicken, Cambs. (*F. W. E.*); Shefford, Beds. (*F. W. E.*); Oxford district (*A. H. Hamm*); Woolhampton, Berks. (*A. H. Hamm*). Besides these, females were wrongly recorded as *S. latipes* in my previous paper from Bovisand, Devon; Corfe Castle, Dorset; and Stockenchurch, Oxon.

Variation.—Very little noticed, but the femora and tibiae of the female vary in ground-colour; the lightest specimens show most distinctly the dark ring near the base of the hind tibiae, while in the darkest it is barely distinguishable. The hind metatarsi are always dark.

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* See synonymy below, and under *S. aureum*.

Blood-sucking.—No evidence.

References and Synonymy.—The female I previously attributed to *S. latipes* really belongs here, together with some of those I included with *S. angustipes*, but the female I formerly regarded as this species is *S. aureum*. The pupa figured by Fries as that of *S. reptans* may be this species; also the pupal filaments figured by Tömösvary (Rovartani Lapok, i, p. 34, 1884) and Horvath (*loc. cit.* p. 195, pl. iii), though attributed to *S. columbaczense*, may belong to this species, as their structure seems identical. In any case the *S. columbaczense* of these writers would seem to belong to the same group as *S. angustitarsis*. Friederichs (Zeitschr. f. angew. Ent., vi, p. 61, 1919) found the species in the river Aar at Bern and figures the male hypopygium and the pupa and pupal filament; the figures have been transposed with those of *S. maculatum* (*i.e.*, *S. latipes*).

13. **S. aureum,** Fries* (figs. 1*k*, 2*m*).

Larva.—General colour dirty greyish or greenish grey, with rather ill-defined reddish-brown markings. Head with five or six well-defined elongate dark marks; two transverse on the posterior margin, three or four longitudinal in the form of a cross, the middle one linear and sometimes divided (making six in all); all these sometimes enclosed in a dark cloud; a dark stripe over the eyes, including a distinct blackish dot. Antennae with the first joint rather swollen, except on its apical fourth, which is rather suddenly narrowed, second joint much more slender but not greatly longer than the first, third half as long as the second, fourth minute. Mentum with 11 sharply pointed teeth in the terminal row, the central one and the second from each end much larger than the others. Two conical papillae on the ventral side of the last abdominal segment. About 70 rows in the anal sucker, each with 12–15 hooks. Skin round anus bare. Gills simple.

Pupa.—Respiratory filaments much longer than the pupa, four in number, all arising almost at the same point, but all practically in the same plane; all equally though very slightly thickened towards the base. Cocoon constructed as in *S. latipes*, but without any trace of a median anterior projection.

Habitat.—Small temporary streams, especially when stony; sometimes also found in rivers, but not in great numbers.

Breeding Season.—My observations are somewhat contradictory and unsatisfactory, but there would appear to be at least two broods in the year, of which that appearing in the early autumn is much the most numerous in individuals. The only definite evidence available as to over-wintering is that Mr. A. H. Hamm took a female in the Oxford Museum, 3.ii.1916.

I found eggs, laid almost certainly by this species, in August 1915, in patches on blades of grass at the surface of the water, and on stones below the water. The eggs are dark brown and hard-shelled, not enclosed in jelly; some which I kept under a dripping tap hatched at the end of a week and the issuing larvae had well-developed egg-bursters, resembling those of *S. latipes*.

Material collected.—Larvae and pupae have been collected as follows:—*Middlesex*: in all the small streams round Harrow, Pinner and Northwood, viii. 1915; most of

* See synonymy below.

these streams had contained *S. latipes* in the spring, but in August only *S. aureum* with (in one case) a few *S. latipes* and an occasional *S. ornatum* could be found ;* in the spring of 1916 *S. latipes* was again abundant, and one or two *S. aureum* were found with it. Harefield, 19.ix.15, one pupa in small weedy stream with many *S. ornatum*. *Bucks.* : stony stream at Burnham Beeches, 10.ix.15. *Devonshire* : one pupa in a small stream at Start Point ; one larva in the river Otter at Tipton St. John, vi.1920 ; one or two larvae and pupae in the river Sid at Sidmouth, vi.1920. *Hants.* : Botley, New Forest, iii. 1915, among water-weeds (*Lady Jenkyns*) ; River Test (*M. E. Mosely*). *Cambs.* : Cambridge Botanic Gardens, 1.x.15 ; larvae and pupae in large numbers on roots of a tree in small stream 10 inches wide by 1 inch deep ; all these had disappeared by Christmas 1915, and at Easter 1916 there were no signs of larvae ; very young larvae were present in June 1916. *Suffolk* : Barton Mills, 30.ix.15, a few pupae in a backwater of R. Lark ; R. Lark near Mildenhall, 25.iv.16, a few pupae with *S. ornatum*, etc., on water-plants. *Lancashire* : Manchester district (*H. Garnett*). *Scotland* : small rills on flanks of Goat Fell, Isle of Arran, v.1919 ; a few pupae among more numerous *S. latipes*. Additional records for the adults are :—Oxford district (*A. H. Hamm*) ; Porthcawl, Glamorgan (*Lt.-Col. Yerbury*). Blyth and Bulwell Hall, Notts. (*J. W. Carr*). Snailbeach, Salop (*F. W. E.*). Possibly a few of the records given previously for *S. latipes* really apply to this species, but both are common and widely distributed.

Variation.—The central mark (or when it is divided, the two central marks) on the head of the larva varies somewhat in shape ; the respiratory filaments of the pupa have sometimes a barely distinguishable stalk to each pair. The stilus of the male adminiculum varies slightly in width and the claspers in shape ; also the amount of hair on the basal pieces of the male genitalia is not constant. The male legs are usually almost entirely dark, but often the basal two-thirds of the femora and tibiae are perceptibly paler, this appearance being heightened by the golden pubescence. There is a variable amount of yellow on the hind metatarsus of the female.

Blood-sucking.—No evidence. I have failed to induce captive females to bite by confining them over my hand, but this is also true of other species.

References and Synonymy.—Rearing experiments have shown that the male and female which I previously described as *S. aureum*, Fries, really belonged to different species ; I now propose to interpret Fries' name as applying to the female described in Bull. Ent. Res. vi, p. 39, noting meanwhile that in that description I had overlooked the fact that the hind metatarsi are usually to a large extent yellow. The male I previously took for *S. aureum* therefore becomes *S. angustitarsis*, Lundstr. ; the male of *S. aureum* is really my *S. angustipes* (Bull. Ent. Res. vi, p. 40) ; this latter name therefore falls as a synonym of *S. aureum*, Fries. Most of the females assumed to be *S. angustipes* do not belong here but are really *S. angustitarsis*.

S. aureum also occurs in North America under the name *S. bracteatum*, Coq. I have examined a male from Spartanburg, S.C., 14.viii.13 (*A. W. J. Pomeroy*) and cannot find any appreciable difference either in the genitalia or in any other character. The larvae and pupae of *S. bracteatum* as described by Strickland (Jl. Morph. xxiv,

* I was at first inclined to regard this as indicating that *S. aureum* was the autumn form of *S. latipes* ; but there are good structural differences between the two species in all their stages.

p. 45, pl. i, 1913) and Pomeroy (U.S. Dept. Agric. Bull. 329, p. 13) also agree almost entirely in structure, coloration and habits with British *S. aureum*, the only difference being in the shape of the larval antennae, which may depend on the preparation.

The pupa has also been figured by Garnett (Trans. Manchester Microsc. Soc. 1914 [1916], p. 10, pl. i) as that of *S. reptans*. The adults described by Corti (Atti Soc. Ital. Sci. Nat. liii, p. 192, 1914, and liv, p. 223, 1916) as *S. aureum* apparently agree with the present interpretation of Fries' species, which is evidently widely distributed in Europe. Dr. G. Enderlein has sent me specimens from the neighbourhood of Berlin; he also had determined them as *S. aureum*. There is an African representative with a wide distribution in that continent, which has recently been described by Pomeroy as *S. aureosimile*.

14. **S. subexcisum,** Edw. (figs. 1*m*, 2*f*, 3*e*, 4*o*).

Larva.—General colour pale dingy yellowish-brown. Head pale yellowish, clypeus with sharply defined black marks; the largest and most conspicuous a wedge-shaped one in the middle near the posterior margin; a small one anterior to this; a pair of small ones rather close together one on each side of the anterior end of the wedge-shaped one; also a transverse black mark at each posterior angle; a conspicuous dark stripe over the eyes, including a small blackish dot. Antennae blackish, very long, 9-jointed, first joint slightly swollen towards the base, about six times as long as broad, followed by four short joints, each a little longer than broad; sixth and seventh rather longer, twice as long as broad; eighth joint very long and slender, as long as the first; ninth minute. Mentum with 9 teeth in the terminal row, the middle one and the two at each end larger than the remaining four; sides of mentum with one or two long hairs. A pair of well-developed ventral papillae on the last abdominal segment. Anal sucker with about 80 rows, each with about 10–12 hooks. Skin round anus bare. Gills simple.

Pupa.—Respiratory filaments long, six in number; the first division is close to the base, into short stems diverging almost at two right angles; the upper stem divides into two branches, which continue in a vertical direction as far as the height of the pupa, then bend forwards along the anterior projection of the cocoon; the lower stem is shorter than the upper, dividing almost immediately into two branches, each of which is forked at some distance from its base. Cocoon as in *S. latipes* with a long anterior projection.

Habitat.—Stones and grass-blades in small temporary streams in or near woods, in company with *S. latipes*, but always comparatively scarce.

Breeding Season.—The few specimens reared were obtained in the late spring. As in the case of *S. latipes*, there cannot normally be more than one brood in the year.

Material collected.—Two males were reared from pupae found on stones in a small rill on Stanmore Common, Middlesex, iv.1916. A single female was reared from a pupa found on a stone in a small stream at Knebworth Wood, Herts., 10.v.1920, and half a dozen larvae were found at the same time and place on stones and grass-blades. In each case the specimens were associated with large numbers of *S. latipes*.

A small number of females were taken at Glen Sannox and Glen Catacol, Arran, v.1919, flying in company with *S. latipes*; also at Gidleigh Park, S. Devon, 2.vi.1920.

Variation.—The pupal filaments dissected from one larva showed a small stump near the tip of one of the vertical branches, or both sides. The smaller dark spots on the larval head vary in size and distinctness.

15. **S. yerburyi,** sp. n. (fig. 4*p*).

Adult female.—Differs from that of *S. subexcisum*, Edw., only in the colour of the vestiture of the mesonotum : instead of being all yellowish, there are three stripes of dark brown, the middle one divided by a line of pale scales or hairs ; the middle stripe is longer than the side stripes, but does not nearly reach the front margin.

Pupa.—Differs from that of *S. subexcisum* as follows :—Vertical stem of upper respiratory filaments shorter, forking near the base, each branch forking a second time at no great distance from the first fork, so that there are eight branches in all.

Material collected.—A single female (the type of the species) was reared from a pupa collected at Knebworth Wood, Herts., 10.v.20, in company with many *S. latipes* and one *S. subexcisum*. There are three other females in the British Museum Collection, from Nethy Bridge, 18.vi.05, and Nairn, 28.v.05. (*Lt.-Col. Yerbury*). These were referred to in my previous paper as a variety of *S. subexcisum*, but since the difference in the female proves to be correlated with a difference in the pupa, it is perhaps preferable to regard the two forms provisionally as distinct species. The male and larva are unknown to me. The discovery of the former may possibly prove the species to be identical with one of those described by Lundström.

16. **S. hirtipes**, Fries (figs. 2*g*, 3*f*, 7).

I have not met with the early stages of this species, and they do not appear to have been described by any European author. Since however the American form described under this name appears to be identical in the adult, the following characters given by Johannsen and Malloch for American specimens will probably hold good for the British race also.

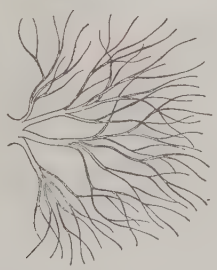

Fig. 7. *Simulium hirtipes*, Fries ; side view of respiratory organ of pupa (from Malloch).

Larva.—Colour of upper surface yellowish on the thorax, fuscous on the abdomen. Head rich brown, posterior margin nearly black. Antennae 3-jointed,* first joint occupying two-thirds of the length. Mentum with 7 teeth in the terminal row,

* This may possibly have been an error of observation on the part of the American writers. The division between the first two joints is always rather indistinct.

all but the outer ones strongly trifid. About 100 rows of hooks in the anal sucker, 12 in a row. Gills simple.

Pupa.—Respiratory tufts much shorter than the pupa, divided near the base into four main branches, the two inner ones larger than the outer ones, each branch again dividing two or three times into twigs, so that upwards of 60 filaments may be counted. Cocoon, a dark matted mass of silk, of no definite form, secreted on the rock, the pupae only partly covered.

Distribution.—Mr. F. Jenkinson has shown me a specimen said to have been taken at Crowborough, Sussex. Otherwise I have no records to add to those previously given, which all referred to the Scottish highlands.

17. **S. tredecimatum,** sp. nov. (figs. 2*h*, 4*q*).

Adult.—Not yet recognised.

Larva.—One of the largest, if not the largest, of the genus. Head markings of the same type as in *S. ornatum*, but more diffused ; a dark dot in the region of the eyes, and a pair about the middle of the clypeus. Antennae 4-jointed, the first two joints membranous, pale, the last two dark ; first and third joints about equal in length, second more than twice as long as either, fourth minute. Mentum with 11 divisions apically ; except for the middle three these are so short and blunt that they can hardly be called teeth ; the divisions are not noticeably trilobed. Sides of mentum with about four long hairs. About 110 rows of hooks in the anal sucker, and about 18–23 hooks in each row. No ventral tubercles on last abdominal segment, but the whole segment is much more swollen ventrally than in most species. Skin round anus bare. Anal gills simple.

One specimen was sufficiently developed to allow the pupal respiratory organs to be dissected out ; these agreed closely with the pupa described below.

Pupa.—Respiratory organ hardly more than a quarter as long as the pupa, divided into thirteen filaments in all. At the base there are four main divisions ; the first of these extends upwards nearly vertically for a short distance, emitting two branches close together near its base and a little higher up dividing into three ; the second divides into two close to its base ; the third and fourth each split into three a little way from the base. No cocoon present in the material available.

The above description has been drawn up from one pupa (evidently freshly formed) and a number of larvae in the British Museum, bearing the label, " from stomach of a trout, England." Most unfortunately no other data are available, but the species is so very distinct in both larval and pupal stages that it seems worth while to describe it, in order to call attention to the existence of such a remarkable form, even though it may ultimately be discovered that there was an error of labelling, or that the adult was already known under another name. There is a bare possibility that the species may be *S. hirtipes*, the early stages of which, as mentioned above, have not been described from Europe. However it seems very unlikely that two forms which are to all appearances identical in the adult stage (as are the American and European races of *S. hirtipes*) should yet differ so widely as larvae and pupae. No species has hitherto been described from any part of the world with 13-filamented respiratory organs in the pupa.

CRAB-HOLES, TREES, AND OTHER MOSQUITO SOURCES IN LAGOS.

By J. M. Dalziel, M.D., B.Sc. (Public Health), F.L.S.,

Senior Sanitary Officer, Gold Coast.

The occurrence of mosquitos in crab-holes is tolerably well known both in West Africa and in other countries. It is doubtful, however, whether these sources receive sufficient practical attention, and one hears too often when their presence is demonstrated the opinion expressed that the insects only shelter there and are not likely to use them as breeding-places when so many others are available. One has even found medical officers whose unbelief had to be assailed by demonstration of the larvae and pupae. Others again, though aware of the fact, perhaps think the occurrence of too trifling importance to justify the necessary steps to eradicate them, even when near a dwelling.

The following notes from Lagos seem to support the opinion that where it can be shown that the imagines caught in houses are of the same species as those found as larvae in crab-holes in the vicinity, an effort to eliminate the latter is called for even at the expense of some labour and cost. In many cases the numbers issuing from a very few holes are so great that even if the species are not those known to be concerned in conveying disease, these efforts are justified if it can be shown that the insects contribute appreciably to man's discomfort. Reasonable comfort is one of the first conditions of health maintenance in the tropics, and the bites of mosquitos, even of those described—perhaps only in our present ignorance—as "harmless," are amongst the many little but important matters which prevent both efficiency and enjoyment of life.

The island of which the town of Lagos occupies the north-western portion is nearly flat, with a tendency to a whale-back contour in the occupied portion. The highest point is not much over 200 feet above lagoon level, and over the greater area water would be found at any depth from 3 to 10 feet, even at a distance from the lagoon margin. The soil is in the main sandy with areas of mud covered with coarse grass on many low-lying stretches towards the water-side. Being entirely surrounded by the comparatively still waters of lagoons and creeks its margins are at no point exposed to the surf of the open coast, and the rise and fall of the tide has only about a 2-foot range. The most familiar crab of the island is a land-crab, inhabiting in great abundance the low grounds near the margins of the lagoon at any point of the island, and travelling across country to any distance, restricted in the present instance by topographical limitations at most points to several hundred yards. This crab is *Cardisoma armatum*, Herklots, and is believed to be possibly identical with the West Indian *C. guanhumi*. It belongs to the Family Gecarcinidae, land-crabs common to the warm regions of both hemispheres. The carapace is entire. It is very abundantly captured for food, being generally trapped on the pit-fall principle by means of a kerosene tin sunk flush with the surface in a likely spot, but being an inhabitant of filthy localities on Lagos Island its use for the table is not to be recommended.

(Another edible crab, *Callinectes* sp. (probably *C. marginatus*), is an article of food which is appreciated even by Europeans. It has a deeply serrated carapace with a longer spine at each end. This is one of the swimming Crabs and is not concerned in the matter of mosquito breeding).

Attention was first drawn to the connection between mosquito prevalence in certain houses and the propinquity of holes of the land-crab by observing the numbers of mosquitos which issued when the holes were disturbed. Collections of adult mosquitos made in the houses showed, in the second place, an almost exact correspondence with similar collections of adults issuing from holes in the garden or on neighbouring ground. Proof was then obtained by finding larvae and pupae in the water of the crab-holes and hatching them out in the laboratory with ultimate determination of the species.

Crab-holes may be found in almost any part of the island, but they are most abundant near the lagoon margins, where the salinity of the water tends to prevent their contributing to the mosquito pest. On the other hand, owing to the proximity of the subsoil-water to the surface all over the island, it may be that every crab-hole, except those daily washed by the tide, is at some time or other a potential source of mosquitos, provided that the water it contains is fresh or only brackish to a moderate degree and remains so for a sufficient number of days.

On certain reclaimed areas in the town, which were originally creeks or inlets from the lagoon, they are particularly numerous. Such areas are generally overgrown with grass, and being at present without proper drainage they have acquired a spongy character, riddled with crab-holes and half-swampy in the rains. In these circumstances Anopheline as well as other mosquitos breed freely, yet little except palliative measures can be taken until a more thorough reclamation with proper grading and drainage can be applied to alter the whole character of the locality. Their eradication is rendered the more important owing to the close proximity of native dwellings with a congested population, along with the observed fact that *Stegomyia fasciata* does not shun the crab-hole, and the regular inspection of premises by the mosquito brigade doubtless tends to drive this domestic species to seek a less disturbed hatching place in the neighbourhood of houses.

Although a considerable amount of routine labour has been devoted to these places in conjunction with general out-door work, most of the details recorded in these notes are the result of efforts directed against crab-holes in the vicinity of European Government Quarters near the lagoon and around the Golf-course at the eastern end of the inhabited town proper. In this area after attention was first drawn to their presence and potentialities it was found that a reasonable amount of properly directed effort was well repaid by results.

A small gang of labourers with native overseers under supervision of a European was detailed in May 1914 for out-door anti-mosquito work, and at first particular attention was paid to crab-holes in or near occupied European compounds. The part dealt with included Government House and various other residences of officials, along with the adjoining grassy slope of the Marina Road towards the edge of the lagoon, the Golf-course itself with the European compounds around it, and an unreclaimed marshy portion of the same area (here referred to as the Golf-course swamp).

The method first employed was to pour down the hole a disinfectant such as cylin, of strength about 1 in 8 or 10, with either cold or boiling water. The latter was found to be more effective in killing the crab and had the further advantage that cheap tar or crude creosote could be used. The boiling of the water on the spot, and the finding of dry fuel in rainy weather, however, involved so much loss of time and waste of effort that a simple solution of cylin or Kerol came to be preferred for use on a fairly extensive scale. (It may be said, however, that for private owners or occupiers troubled with a few crab-holes large enough to breed mosquitos, the occasional use of a bucket or two of boiling water mixed with Stockholm tar is a tolerably effective procedure. The crab either perishes in the hole or is dealt with in attempting to escape.)

From 7th to 31st May 1914, 7,250 crab-holes were treated, and 1,805 from 1st to 15th June; total 9,055. After the middle of June on the other hand an accurate count was not attempted, as the rainfall brought the water near the surface, and in parts of the Golf-course area many holes lost their individuality in open pools and marshy spots. In fairly well-drained compounds they ceased to be found in more than small numbers where they had abounded a few weeks previously, and in many of these a periodic visit to deal with new holes was all that was required thereafter. As the number of compounds was considerable, and as crab-holes formed only one source of the mosquito trouble, it was found desirable in practice to make this work part of a regular routine, and as no means has so far been found to prevent a fresh access of crabs a certain amount of labour devoted to these continues to be necessary. The above figures therefore indicate the tentative work of the first few weeks.

After the first efforts it was found that in a proportion of cases the crab survived and the hole reappeared in a day or two. Thus in a series of compounds 1,045 crab-holes were dealt with by a first treatment with a disinfectant followed by obliteration of the hole. Of these 260 or 24·8 per cent. were found on a second visit to have reappeared. After a second treatment of these still a few persisted, and some of them had to be dealt with by other methods. In one compound situated within 100 yards of the lagoon edge, where various conditions were particularly favourable to the crab, over 1,000 holes were dealt with in the course of several visits.

An objection to the use of tar or disinfectants in private compounds was found to be discoloration of grass or injury to plants, etc., and eventually the practice adopted for general use was simply to dig out the crab. Even by this method the creature occasionally defied discovery, either being absent, or, as proved by observation, having retreated to another gallery beyond the watery pocket at the bottom of the hole.

The depth to which it is necessary to dig depends on the time of year and on local circumstances determining the distance of the water from the surface. The burrow is naturally oblique in direction, and a vertical depth of 3 feet has sometimes to be dealt with, the deepest measured being one or more in which larvae were recovered at nearly 4 feet from the surface. One such hole at the depth of 4 feet was followed for a further distance of 2 feet in a horizontal or slightly upward direction. It is obvious that mere obliteration of the hole without destruction of the crab is waste of time, except in virtue of removal for the time being of one mosquito breeding place, soon to be renewed.

A single hole may furnish eggs, larvae of all stages of growth, living pupae and empty pupal cases, indicating uninterrupted use by female mosquitos for several generations. The fact that in the great majority of cases the imagines captured were unfed and apparently quite recently hatched, supported the assumption that the insects were actually occupying the location of their birth. Other specimens are probably females returning to lay eggs. On one occasion several holes along the base of a line fence, which had been treated with tar emulsion a few days previously without obliteration of the burrows, were found to harbour adult mosquitos. On digging these out tarry water and tar-soaked soil were found but no larvae and no crabs either dead or alive. Probably the amount used had been insufficient and the creatures had succeeded in escaping through the soil from the end of the gallery or by another bolt-hole ; the mosquitos were either dislodged individuals sheltering, or gravid females preparing to lay eggs.

Conditions which interfered with the work of eradication were mainly due to the frequent occurrence of the holes along lines of fencing planted with shrubs and trees separating one compound from another, under clumps of banana trees, at the roots of ornamental plants, or at the edge of cement drains or masonry.

Work on the above lines has been continued as circumstances demand up to the present time. Along the Marina in the main business street of the town numerous and very large crab-holes are found in which at times multitudes of mosquito larvae can be demonstrated. Probably the ultimate disposal of these will be through extension of the macadamised road surface to cover the whole space from the warehouses to the concrete sea-wall.

In Bathurst crab-holes have been found to be a prolific source of Culicine mosquitos. As digging in of the holes failed to stop the nuisance, the crab making a fresh outlet, the method adopted with success in some cases was to fill in with chloride of lime and stamp down (Annual Med. and Sanit. Report for Gambia, 1914, p. 13).

Species of Mosquitos found in Crab-holes.

In the years 1914 to 1918 inclusive numerous samples of larvae found in crab-holes were obtained and sent to the Medical Research Institute at Yaba.* There is no continuous record for all the consecutive months of any single year, and during the months of greatest rainfall, when more anti-mosquito work is done in the way of oiling and ditching on a wider scale, samples from individual crab-holes were less frequently sent, but the total number is sufficient to be of some value, and every month in the calendar is represented.

On several occasions also adult mosquitos were captured in the holes for comparison, both with those found in neighbouring houses and with those ultimately hatched out in the laboratory from larvae collected at the same time.

No note has been made of other inhabitants of crab-holes such as Copepoda and insect larvae other than CULICIDAE ; it is probable that species of *Culicoides* and other so-called " sand-flies " will be found amongst those enjoying the same habitat.

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* I have to thank the Director, Dr. A. Connal, for undertaking their investigation and Mrs. Connal for identifications of the numerous mosquitos obtained from these and from various other sources.

(1) *Mosquito Larvae in Crab-holes.*

From the samples sent to the laboratory, 14 species have been hatched. The following table gives the names of these and the number of occasions on which each was found.

TABLE I.

Species of Mosquito.	No. of times found.	Percentage of total finds.
Ochlerotatus irritans	95	34·6
*Culex decens**	43	15·7
Uranotaenia annulata	41	15·0
Ochlerotatus nigricephalus	22	8·0
Stegomyia fasciata	20	7·3
Anopheles costalis	20	7·3
Culex insignis	13	4·7
Culiciomyia nebulosa	9	3·3
Culex thalassius	4	1·4
„ *rima*	3	1·1
„ *salisburiensis*	1	·4
Uranotaenia bilineata var. *fraseri* ..	1	·4
Stegomyia luteocephala	1	·4
Micraëdes inconspicuosus	1	·4
Total	274	

* Here and throughout this paper *C. invidiosus* is merged in *C. decens*.

The number of samples is sufficiently large to give fairly representative results, and it may be accepted that *O. irritans* is the species most often found. A further claim to priority in this respect is that it is not infrequently the only species found, and that it often hatches out in very large numbers from a single hole. Its occurrence in this habitat may be confidently expected in any month of the year, though perhaps the months of April, May and June have shown a preponderance of finds for this species.

Its congener *O. nigricephalus* has the same seasonal range, but is far behind it in numbers. The former uses many other breeding places, but the only other common source for the latter has been surface pools, and once its larvae were found in a canoe. Both are vicious biters and are commonly caught in houses.

Culex decens is well entitled to the second place. Its larvae seem to be less hardy than the others and are more difficult to hatch. The journey to the laboratory from the sources of collection is about 6 miles, and the agitation of the bottles used in conveying the larvae is perhaps more than some can stand. *C. decens* may be found at any time of year, but samples in the months of January to April have shown a greater proportion of this species. Its other habitats show almost as great a diversity as those of *S. fasciata*, and the adults have been found in dwelling houses in every month of the year. The third place on the list is taken by *U. annulata*, a species which has also been found in each month of the year, but which seems to have a special prevalence about January and February, when it often exceeds *O. irritans*. Unlike the latter its adults are comparatively rare in houses except in the immediate vicinity of some prolific nidus. Its other sources are small swamp pools and wells.

Stegomyia fasciata and *Anopheles costalis* tie for the 5th place, but with two important distinctions, viz. (1) the occurrence of *Stegomyia* larvae has shown no regularity in number or in season of year, while *Anopheles* larvae have been found in crab-holes only in the period June to October ; (2) the localities of the respective sources (as recorded with each sample) have indicated for *Stegomyia* either the compound of a dwelling house (European or native) or a place in comparatively close proximity ; in a few instances the Golf-course swamp is indicated, of which probably no part is much more than 200 to 300 yards from dwellings of some sort ; in the case of *Anopheles* the nature of the recorded notes, *e.g.*, " in crab-holes full of rain-water," " along with tadpoles, etc.," indicate along with the stated localities either a temporary meteorological condition or a permanent comparatively water-logged site as a constant accompanying factor. In many cases Anopheline larvae, often visible within the hole at a depth of a few inches, may have arrived there with the retreat of the water from the surface pool or swamp on which the eggs were laid.

Culex insignis furnished about 5 per cent. of the recorded finds, but occurred in small actual numbers. No special seasonal incidence is suggested, and although it has been found in dwelling-houses, and perhaps oftener in out-houses, it is not a particularly domestic species.

Culiciomyia nebulosa shares with *S. fasciata* the distinction of being the most domesticated of the mosquitos ; indeed, its preponderance in organically polluted water or vegetable infusions in households probably gives it precedence in this respect in Lagos. Its occurrence in crab-holes is thus, as would be expected, less frequent, and generally in occupied compounds, though it has also been found in the Golf-course swamp.

Of the remaining species in the above list one may say that *C. thalassius* as a lover of brackish water, though not dependent on it, is likely to be a more common inhabitant than here indicated of crab-holes in localities where this condition prevails, *e.g.*, the tidal swamps at certain places on the island or neighbouring mainland at such a distance from the inhabited areas as to be beyond the radius of our special work. The species is common in houses in the vicinity of and to leeward of its breeding places, and bites freely. *C. rima* occurred in the vicinity of the Golf-course, and its adults were found in European houses, stables, etc., of the same locality, but no other breeding place has been observed.

The 4 species at the end of the list are apparently exceptional. The larvae of *S. luteocephala* were associated in the crab-hole with those of *S. fasciata* and *C. nebulosa*, while about the same date the larvae of the first-named were found in the fork of a tree in the same European compound. Adults have been taken occasionally in houses of the neighbourhood. Those of *C. salisburiensis* have been found several times in surface pools, and the imagines at least once in a house of the same locality. No other source of the larvae of *M. inconspicuosus* and *U. bilineata* var. *fraseri* has come to notice ; imagines of the former have not been captured, but those of the latter have at times shown a localised prevalence and at one time abounded in in the rooms of Government House itself. The occurrence of more than one species of larva in one crab-hole is common, and in fact perhaps almost usual. The two

species of *Ochlerotatus* were often associated. *C. decens*, *C. nebulosa* and *U. annulata* were all hatched from one sample. In another instance *O. irritans*, *O. nigricephalus*, *U. annulata* and *C. nebulosa* were in association.

(2) *Adult Mosquitos in Crab-holes.*

A few collections were made of imagines found in crab-holes. The dates of these fall between the months of May and October, 1914, and representatives of 17 species were determined, viz.:—

Ochlerotatus irritans
,, *nigricephalus*
,, *caliginosus*
,, *punctothoracis*
Culex decens
,, *insignis*
,, *thalassius*
,, *rima*
,, *salisburiensis*
Culex fatigans
,, *consimilis*
Uranotaenia annulata
,, *bilineata* var. *fraseri*
Culiciomyia nebulosa
Mansonioides africanus
Anopheles costalis
Stegomyia fasciata

The order of arrangement in the above list is not necessarily that of frequency of occurrence, and the number of individuals caught was insufficient for a true estimate of relative abundance of each species. A comparison of the two foregoing lists shows (1) that of the 14 species bred from larvae 2 have not been captured as adults in the crab-holes, viz., *S. luteocephala* and *M. inconspicuosus*, of which the larvae were obtained only once each; (2) that of the 17 species caught in the winged state 5 are not represented in the list of larvae, viz., *O. punctothoracis*, *O. caliginosus*, *C. fatigans*, *C. consimilis*, and *M. africanus*. If these 5 could be regarded as occupying at the time of capture their place of hatching, the number of species definitely associated with crab-holes would be 19. The peculiar habit however of the larva of *M. africanus* in relation to the roots of the water lettuce (*Pistia stratiotes*) suggests its being only a temporary visitor after hatching in a pool or swamp near by (the locality was the Golf-course swamp and the month July in the rainy season).

With regard to the other 4 species, the larvae of *O. punctothoracis* and of *O. caliginosus* have not been found in any of the collections from any source in Lagos during the period covered by these notes, but both have previously been obtained from borrow-pits on the mainland within the municipal area.

The adults of both species have been caught occasionally in the houses of Europeans, and those of *O. caliginosus* were accompanied in crab-holes at a considerable distance from other possible breeding places by those of *C. decens*, which has already been shown to be one of the commonest species hatched from this type of nidus. *C. consimilis* has been bred from larvae taken from wells in Ebute Metta (on the mainland within the municipal area), and the adult appears not very infrequently in collections from the houses of European officials in Lagos itself. In crab-holes the mosquito was accompanied by adults of *C. decens* and *S. fasciata*, while all 3 species were captured simultaneously in adjoining European quarters. *C. fatigans* has been hatched from larvae found in wells and barrels, and occasionally in a boat or canoe. It is not a common mosquito in Lagos, but has been caught in European houses. It is probable that all 4 species occasionally make use of crab-holes as breeding-places.

Relation of Crab-hole Mosquitos to Human Beings.

With reference to the possible influence of crab-holes on the prevalence of mosquito-borne diseases, the question will have to be decided on its merits in each different locality. In Tropical America two species, viz., *Culex extricator* and *Deinocerites* sp., have been found to "breed abundantly and exclusively in crab-holes," but no evidence exists that either enters houses or shows any attraction towards human beings, nor was blood ever found in the females of the *Culex* examined (Knab, in "Science," June 1910, p. 869). Crab-holes in mangrove swamps of Brazil were found to yield (along with CERATOPOGONINAE) *Culex reticulatus*, Lutz, *C. corniger*, Theo., and *C.* (*Culicelsa*) *taeniorhynchus*, Wied. (Rev. App. Ent. i, p. 64), but there is no mention of their habits in relation to man. In the Panama Canal Zone crab-holes were dealt with in tens of thousands.

According to the late Prof. Rubert Boyce, referring to Barbados, "In many of the more low-lying swampy coasts crab-holes occur in enormous numbers in the sandy soil, and in them are bred out vast numbers of mosquitoes. In fact they constitute the chief nuisance in those houses which are situated near the sea." ("Mosquito or Man," p. 96). Howard, Dyar and Knab ("The Mosquitoes of North and Central America and the West Indies," p. 1) take exception to this and indicate that crab-hole mosquitos, as observed by them, do not molest man, and therefore their destruction need not be considered. It is apparent, however, that the species under consideration by these observers differ in habit from those observed by Professor Boyce, and this in turn is probably related to the important particular of special adaptation, and the authors' conclusion must be read in the light of their statement that the mosquitos that breed in crab-holes are "specialised forms of *Deinocerites* and related genera," and that there also occur "a number of species of *Culex* peculiar to the crab-holes and even structurally these show more or less adaptation to their habitat." (*loc. cit.*, p. 149).

In Lagos, of the species bred from larvae in crab-holes, all those which occur there in appreciable numbers have been found also in a variety of other sources. No species has yet been found here which shows a special adaptation structurally to this form of habitat.

Three of the species mentioned in Table I have not, in connection with the present observations, been obtained as larvae from other sources, viz., *C. rima*, *U. bilineata* var. *fraseri* and *M. inconspicuosus*; of these the two last named were each found once only. It is unlikely therefore that the relationship in the case of these three has any importance from the point of view of endemic disease. But the crab-holes which produce abundance of possibly harmless species also furnish breeding-places for no inconsiderable numbers of those credited with the spread of disease.

The probable effect of daily house-to-house inspection, with the main object of preventing breeding of domestic mosquitos, in driving the *Stegomyia* out of doors has already been referred to. In circumstances such as those in Lagos, therefore, the crab-hole in proximity to dwellings (a qualification which applies to practically the whole of the inhabited area) deserves attention as an accessory domestic breeding-place of the known vector of yellow fever.

The connection of *Anopheles costalis* with crab-holes, I believe, on the other hand to be more or less accidental and dependent on the flat contour and generally

low-lying and water-logged state of considerable areas of the island. It is doubtful if at any time of the year the female *Anopheles* finds it necessary to enter the shadow of a crab-burrow for purposes of egg-laying, at least to a distance beyond the range of ordinary daylight. War against the crab will therefore not be expected to have more than a subsidiary effect on the reduction of *Anopheles*, which must be dealt with by larger measures of drainage, oiling, etc., in view of the very numerous facilities afforded to that species on Lagos Island.

Apart from *S. fasciata* and *A. costalis*, both carriers of *Filaria bancrofti*, the crab-holes do not appear in the present instance to be of particular importance in connection with filarial disease.

In addition to supplying an extra and almost domestic source of *S. fasciata* (in itself a factor of sufficient importance) and to the possibly noxious—though still undiscovered—quality of some of the other species to which crab-holes afford unlimited breeding-places, there remains an adequate reason in Lagos for the eradication of crab-holes in the mere fact of the numbers of mosquitos which they supply, of types which have been demonstrated as entering houses and preying upon human beings, even if they should be of secondary importance in relation to the spread of endemic diseases. It is quite a common occurrence for the sanitary gang to bring to light a sample of water from a single crab-hole containing many hundreds of larvae in all stages, and the ocular demonstration of the same to the occupier of adjoining premises has at times been adopted in the interests of propaganda, or to convince a complainer that the seemingly interfering methods of the workers are in reality well directed. From such a source when undetected amongst grass or under foliage, perhaps within a few feet of a dwelling-house, there may issue scores of mosquitos daily and there seems nothing to prevent this continuing for weeks or months as long as the burrow is occupied by the crab. There is unfortunately nothing to suggest that the land-crab includes mosquito larvae in its diet.

A desirable consummation would be to keep the crab at a distance and prevent its access to the neighbourhood of dwellings ; but with a creature which exists in such numbers on the neighbouring sea-margin and which travels purposefully and with ease overland, up drains, etc., this seems at present impracticable, and some of the largest burrows may be found alongside a solid sea-wall or cement drain.

Species of Mosquitos found in Tree-holes.

Commencing in the rainy season of 1915 a regular search for breeding-places in trees was carried out. A ladder was used and sometimes a syringe with flexible rubber tubing. In a few months most of the trees in the public streets were dealt with, as well as many in private compounds. Hollows in tree-forks and holes in decayed wood or in cut branches were treated either by cement or other material, or by cutting out so as to prevent accumulation of water. In later seasons, so far as trees in public places are concerned, only an occasional routine inspection was required, but doubtless in private premises many escape attention. On only two occasions was a second find made in the same tree.

In 1915, May to October, mosquito larvae were found on 43 occasions in 15 different species of tree or plant. For 1916 there is no record, but in later years others were

found; e.g., in 1917, an exceptionally wet year, there were 20 finds in 14 species, and the total up to June 1919 includes 74 occasions in 27 different species. Rot-holes in cut timber are not included, nor are the rotting stumps of banana plants, which, when not rooted out, are a most prolific source of *S. fasciata* in native compounds. Samples of larvae were procured in a majority of instances, and the following six species of mosquitos were determined after hatching :—

TABLE II.

Species of Mosquito.	No. of times found.	Percentage.
Stegomyia luteocephala	33	61
,, *fasciata*	15	28
Culiciomyia nebulosa	2	11
Culex decens	2	
Ochlerotatus apicoannulatus	1	
Uranotaenia annulata	1	
	54	

Apart from one or two exceptions from neighbouring villages within the municipal area, the Lagos samples were all from the town proper, including the native town and the area around the Race-course and Golf-course. The preponderance of *S. luteocephala* is obvious in this list and seems to be out of proportion when compared with tree-bred species in the Gold Coast and Sierra Leone. Other sources of this species in Lagos have been as follows :—Crab-hole (once only), a pool, the metal socket of a telegraph pole, and roof-gutters (similarly in Accra). In Freetown, Sierra Leone, its chief source was in hollows at the roots of the silk-cotton tree (*Eriodendron orientale*), occasionally in rock-holes, rarely in domestic utensils, and once in a coco-yam plant (Bacot—Report on Entomological Investigation undertaken for the Yellow Fever (West Africa) Commission, Aug. 1914 to July 1915).

The larvae of *O. apicoannulatus* have not been found in Lagos (during the course of these observations) except on the one occasion in a tree-hollow (a mango). In Freetown, Bacot (*loc. cit.*) gives its sources as water-holes at the roots of *Eriodendron* and also rock-pools and occasionally tins. In Accra they have been obtained from a flamboyant tree in company with three species of *Stegomyia* (Ingram and Macfie, Bull. Ent. Res. viii, p. 145). A curious find in a banyan tree was *S. luteocephala* in a hole, and *S. fasciata* in a salmon tin lodged in the fork. In another banyan three species were found, viz., *S. luteocephala* in excess, along with *S. fasciata* and *Culic. nebulosa.*

One species in the above list I do not remember having seen in records from others places, viz., *U. annulata*, found once alone and abundant in an ornamental screw-pine (*Pandanus veitchii*) at Government House. *S. africana*, along with *Ochlerotatus marshalli*, has been found by Graham in a cut bamboo, and *O. longipalpis*, Grünb. (*S. pollinctor*, Graham) in a hollow tree at Yaba (Bull. Ent. Res. i, pp. 28–31).

The commonest shade or ornamental trees planted or found growing naturally in Lagos are banyans (several species), mango, flamboyant, West Indian almond, Egyptian acacia and rain tree. Of the non-indigenous trees the flamboyant seems to be the most liable to rot-holes either in the fork or in the stump of a cut branch, and these holes generally retain water. The following list gives the names of the trees in which mosquito larvae were found; in two cases no record was made of the kind of tree by the finder.

TABLE III.

Common Name.	Botanical Name.	Number of Occasions.
Banyan (4 species)	*Ficus thonningii* ,, *platyphylla* ,, *populifolia* ,, sp.	22
Flamboyant	*Poinciana regia*	13
Mango	*Mangifera indica*	6
Pawpaw	*Carica papaya*	5
Woman's Tongue or Egyptian Acacia	*Albizzia lebbek*	4
"Miraculous Berry" (Yoruba—*agbayun*)	*Sideroxylon dulcificum*	
Almond Tree	*Terminalia catappa*	
Black or Velvet Tamarind ..	*Dialium guineense*	
Rain Tree	*Enterolobium dulcis*	
Breadfruit	*Artocarpus incisa*	
Guava	*Psidium guayava*	
Akee Apple	*Blighia sapida*	
Queen of Flowers	*Lagerstroemia regina*	
(Yoruba—*akoko*)	*Newbouldia laevis*	
Cashew	*Anacardium occidentale*	
——	*Sterculia barteri*	
Alexandrian Laurel	*Calophyllum inophyllum*	
——	*Millettia sanagana*	
Orange	*Citrus aurantium*	
Cock-hat Tree (Yoruba—*piregun*)	*Dracaena fragrans*	
Coconut	*Cocos nucifera*	
Ornamental Amaryllid	*Crinum giganteum*	
Ornamental broad-leaved Screw-pine	*Pandanus pacificus*	
Ornamental striped Screw-pine ..	*Pandanus veitchii*	

The five species last named have not proved to be of as much importance as might be expected in Lagos with an average annual rainfall of about 75 inches, the number of larvae found under conditions likely to ensure full development being small. A notable absence from the list is the banana plant, which appears in some places to be a likely and important habitat. Possibly bananas have received less direct attention in Lagos than they deserve, but a good many trees have at different times come under my own observation without one positive find. On the other hand the stump left in the ground after removal of the decayed stem is an abundant and often neglected source of *S. fasciata*. The pawpaw is a source which is apt to be overlooked. The stem substance is soft and quickly decays, and a stump or cut branch containing a rotting hollow is soon concealed by the foliage of fresh young shoots. Also the stem of the healthy tree is hollow with incomplete partitions. A lateral perforation, caused probably by an insect, is frequently present and allows access to mosquitos. Sources of such a nature may remain

unnoticed for weeks or months and are commonly situated close to dwelling-houses. The vertical depth of the cavity in the interior of a pawpaw tree which was discovered to be the source of *S. luteocephala* and *C. nebulosa* captured in a neighbouring bungalow, was found on cutting it open to be 6 feet.

The number of different species of trees harbouring either *S. luteocephala* or *S. fasciata* or both is considerable, and as regards the latter there is perhaps a predilection for banyans. Out of 33 occasions when *S. luteocephala* was identified, 13 were from banyans (12 from the commonest species, viz., *F. thonningii*) and 8 from the flamboyant. The occurrence of the different mosquitos in respect of trees was as follows: —

S. luteocephala in banyans, 13 ; flamboyant, 7 ; mango, 3 ; Egyptian acacia, 3 ; miraculous berry, 2 ; rain tree, 1 ; velvet tamarind, 1 ; almond, 1 ; cashew, 1 ; pawpaw, 1.

S. fasciata in banyans, 6 ; flamboyant, 3 ; mango, 1 ; Egyptian acacia, 1 ; breadfruit, 1 ; *Sterculia barteri*, 1 ; coconut, 1 ; screw-pine, 1.

C. nebulosa in banyan, 1 ; pawpaw, 1.

C. decens in banyan, 1 ; flamboyant, 1.

O. apicoannulatus in Egyptian acacia, 1.

U. annulata in screw-pine, 1.

Collateral observations on tree-breeding species in West Africa are referred to here for convenience of those interested in the subject.

Sierra Leone (*fide* Bacot, *loc. cit, supra*).—In Freetown the " Cock-hat " tree or " Cockade Bush "* holds sufficient water in the axils and central leaf-whorl (in the same manner as the pineapple and other plants) to be a likely source of mosquitos. The breeding-place of two species in Freetown, viz. *Uranotaenia ornata*, Theo., and *Eretmopodites dracaenae*, Edw., seems to be restricted to this plant and to the similar conditions to be found in the coco-yam and the banana. Other species yielded by the " Cock-hat " tree are *S. simpsoni*, and occasionally *S. fasciata* and *C. nebulosa*.

The silk-cotton tree affords in hollows enclosed by the buttresses and amongst its spreading roots breeding-places for the following :—*S. fasciata*, *S. simpsoni*, *S. luteocephala*, *O. minutus*, *O. apicoannulatus*, *C. nebulosa*, *A. costalis*, and *C. decens*.

The coco-yam (*Colocasia antiquorum*) yielded most commonly *S. simpsoni* and *U. ornata* ; also *C. nebulosa* and *S. fasciata*, and a few *E. dracaenae*. *S. simpsoni* was found in banana plants, and *S. fasciata* in numbers with a few *E. dracaenae* in the sarsaparilla (*sic*).

Gold Coast (*fide* Ingram and Macfie, Bull. Ent. Res. vii, 1916, p. 3 ; viii, 1917, pp. 137, 145, 146).—The flamboyant has yielded most samples in Accra, but mango and other trees are also sources. Five species of *Stegomyia*, viz. *S. luteocephala*, *S. fasciata*. *S. metallica*, *S. simpsoni*, and *S. unilineata*, have been found, generally several species in association with each other or with *O. apicoannulatus*, Edw. Larvae of *Cyathomyia fusca*, Theo., were obtained from a flamboyant tree

* This plant is an ornamental shrub of the Nat. Ord. Liliaceae, and is commonly planted along boundary fences in the coastal regions throughout West Africa. In Nigeria its Yoruba name is *piregun* and botanically it is *Dracaena fragrans*, though possibly other species may be included. Its popular names refer to the decorative use made of the leaves by the Sierra-Leonians on festive occasions. J. M. D.

along with those of *A. costalis*, *A. marshalli*, *S. fasciata*, and *S. luteocephala*. In the Northern Territories of the Gold Coast, Ingram (Bull. Ent. Res. x, 1919, p. 50, *et seq.*) found amongst trees near dwellings that those which showed rot-holes most commonly were the flamboyant, wild fig trees, mangos, silk-cotton trees, "dawa dawa" (*Parkia biglobosa*) and tamarind. Larvae of *S. fasciata*, *C. invidiosus*, and *S.* ? *unilineata* were found; also *C. nebulosa* at Kintampo in North Ashanti.

In other countries, the larvae of *Ochlerotatus* (*Culicada*) *ornatus*, Mg., have been found in the horse chestnut (*Aesculus hippocastanum*) in Italy, and those of *Stegomyia* sp. in a tree fork and in cut bamboos at Hanoi, Tonkin. In the Lagos list no Anophelines appear, but in Freetown *A. costalis*, and in Accra both *A. costalis* and *A. marshalli* appear as facultative tree-breeding species.

In India *A. culiciformis*, Cogill, and *A. plumbeus*, Stephens (syn. *A. barianensis*, James, and *A. nigripes*, Staeger) are believed to be essentially tree-hole mosquitos (Christophers, Ind. Journ. Med. Res. iii, pt. 3, Jan. 1916, and Christophers and Chand, *ibid.* pt. 4). The last-named, which has also been obtained from trees in Mesopotamia, freely enters houses and sucks blood. The related American species *A. barberi*, Coquillet, has a similar habitat. The larvae of *A. plumbeus* have been found in tree-holes both in England (Burnham Beeches, Liverpool, etc.), Scotland (Culross), and Ireland (Armagh, Derry, and Louth), in beech, horse-chestnut and elm. In Liverpool district and Cheshire *A. plumbeus*, either alone or in association with *Ochlerotatus geniculatus*, Ol., have been obtained in large numbers from tree-holes, the trees found most favourable to the insects being the elm, horse-chestnut and sycamore (Blacklock and Carter, Ann. Trop. Med. Parasit. xiv, pp. 115–126). In Edinburgh this species was found fairly abundantly some years ago in a well-wooded residential district on the south side of the town. The larvae were not found, but in the absence of any discovered source the suspected tree-holes were cemented up, with apparent reduction of the mosquito in the neighbourhood.

Mosquitos breeding in Wells.

In the period 1914 to 1918 inclusive, 12 species have been obtained as larvae from wells. The 265 samples from which determination of the imagines was made yielded results shown in the following table:—

TABLE IV.

Species of Mosquito.	Number of Occasions.	Percentage.
Stegomyia fasciata	136	51·3
Culex decens	39	14·7
Anopheles costalis	35	13·2
Ochlerotatus irritans	18	6·8
Culiciomyia nebulosa	12	4·5
Culex tigripes	6	2·3
„ *fatigans*	6	2·3
„ *grahami*	5	1·9
„ *duttoni*	3	1·1
Uranotaenia annulata	2	·7
Culex consimilis	2	·7
„ *insignis*	1	·4
Total	265	

The first five species in the list practically always occur in the same order in samples taken from wells, provided that a fair number are examined. *C. decens* favours nearly as great a variety of breeding places as *S. fasciata*. *A. costalis* tends to be relatively more frequent in wells located on vacant premises. *C. tigripes* was always in association with one or more of other species, viz., *S. fasciata*, *O. irritans*, *C. duttoni*, *C. grahami* and *C. fatigans*, the larvae of the former preying on those of the latter. The larvae of *C. consimilis* have not been found (in the course of the work covered by these notes) except on the two occasions in wells, where they were also associated with *S. fasciata*. The adults have been captured in various houses of European officials and in crab-holes on the same premises.

Mosquitos breeding in Boats and Canoes.

A weekly inspection of boats and canoes around the foreshore is made and gives an opportunity for ascertaining the species which frequent them as breeding-places as shown in the list below :—

Species of Mosquito.	Number of Occurrences.
Anopheles costalis	9
Stegomyia fasciata	7
Culiciomyia nebulosa	6
Culex thalassius	5
„ *sitiens*	3
„ *fatigans*	2
Ochlerotatus irritans	1
„ *nigricephalus*	1
Anopheles funestus	1
Culex duttoni	1
	36

A. funestus was an unexpected find, and in spite of the existence of numerous apparently suitable conditions on the island it does not appear in any of my lists apart from this one, either as larva or adult. It is more abundant in fresh waters far from the sea.

In a majority of cases the water in these sources is brackish, being lagoon water diluted by rain or *vice versa*. Under these conditions, although *C. thalassius* does not head the list, it is probably the most abundant survivor; *e.g.*, in a canoe containing distinctly brackish water, numerous larvae of *C. thalassius* and *A. costalis* occurred, but of the sample obtained, only one imago of the latter hatched out, while most of the former went on to full development.

In the instances in which *C. sitiens* was found, the water was decidedly salt to the taste, and the imagines hatched out readily in the samples obtained. Analysis showed 1·8 per cent. estimated as chlorine, an equivalent of 2·99 per cent. sodium chloride. The larvae of this species have not been found in other sources during these observations. It has been recorded from Port Sudan in a pot sunk in salt water (Theobald, Mon. Cul. v, p. 388).

The question of salinity in water samples harbouring mosquito larvae complicates the estimation of true prevalence of different species, some being more sensitive than others to variations of this nature. *C. sitiens* appears to be a true salt-water species, whereas *C. thalassius* is very adaptable, and though breeding abundantly in brackish marshes and lagoons such as those at Bathurst, Accra and Lagos, it is quite commonly found in perfectly fresh water. *O. irritans* seems to breed in brackish pools in the Accra lagoon with a salinity of 1·4 per cent. chlorine (=2·2 per cent. NaCl). The following observation, however, suggests the need for discrimination as to the actual conditions under which larvae will not only remain alive, but proceed to full development. Very numerous larvae were obtained from two crab-holes close to the edge of the Lagos lagoon. The water was salt to the taste, with a salinity equivalent to 2·31 per cent. NaCl. Part of the sample was diluted with fresh water, while the rest was kept as obtained. From the former, *O. irritans* hatched out abundantly for several days; from the latter numerous imagines of the same species hatched on the afternoon of the day on which the sample was collected, and on the following two days only, after which no further development of the numerous remaining larvae occurred. It is probable that the crab-holes, originally containing comparatively fresh water, had been filled by a tide, and that the mosquitos which hatched on the first two days were those which had already pupated or which were ready to pupate at the time the sample was taken. In such a situation the water in a crab-hole may show many fluctuations in degree of salinity and tonicity, with their accompanying alternations of effect on the development of insect larvae, retarding the immature, but probably hastening the pupation of those far advanced.*

Mosquitos breeding in Agbo Pots.

The herbal infusions known as *agbo* are found in most native houses, especially where there are young children, and the receptacles are commonly concealed to escape the weekly inspection. They are very numerous, and sometimes the pots are of large size. On disturbing an *agbo* pot or calabash of long standing, the number of insects which escape is almost incredible, and in many cases the fluid is a seething mass of Culicid and Psychodid larvae and pupae, along with the exuviae of their innumerable predecessors. From 450 samples of larvae from *agbo* the following species were obtained:—

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* Reference may be made to salt-water species occurring elsewhere:—*Acartomyia* (*Aëdes*) *zammittii*, seems to live only in pools left after high water (Dardanelles). *Stegonocops* sp. and *Aëdes fluviatilis* (*Culex fluviatilis*, Lutz) occur in rock-pools with concentrated sea-water (Panama). *Culex sollicitans*, Walk., is almost confined to salt pools near sea-beaches (Howard, Dyar and Knab, "The Mosquitoes of N. and Central America and the W. Indies," i, p. 150). *C. sollicitans*, Walk., occurs in the mud of salt marshes (India, Karachi). *Culex* (*Aëdes*) *cantator*, Coq., *C. taeniorhynchus*, Wd., *C. salinarius*, Coq., with *C. sollicitans*, are found in the coastal salt marshes of America (Connecticut, etc.). Species of *Taeniorhynchus* and *Anopheles* occur in brackish marshes and mangrove swamps, and *Anopheles subpictus* (*rossi*) in brackish wells and salt-water tanks (India). *A.* (*Pseudomyzomyia*) *ludlowi*, a malaria carrier in the Andamans, breeds in salt swamps and mud flats. *Anopheles multicolor*. Camb. (*Pyretophorus* sp.) was found in Egypt in water with 2·56 to 3·25 per cent. NaCl (Willcocks, Ann. Trop. Med. Paras. iii, 5, pp. 586–587.)

TABLE V.

Species of Mosquito.	Number of Occasions.	Percentage.
Culiciomyia nebulosa	396	88
Stegomyia fasciata	51	11
Anopheles costalis	2	
Culex decens	1	1
,, *tigripes*	1	

Culex tigripes occurred in association with both *C. nebulosa*, and *S. fasciata*. *S. fasciata* occurs either alone or more often in association with *C. nebulosa*, but the latter, apart from its preponderance in number of finds, undoubtedly furnishes immeasurably more imagines from this particular source than the former. This mosquito is exceedingly common in native houses and probably at present greatly exceeds *S. fasciata* in numbers (see below). Although a considerable number of ordinary water-pots are concealed or placed in locked rooms during the inspector's visit, there can be no doubt that the weekly inspection of premises is successful in detecting by far the greater number of domestic receptacles which contain *Stegomyia* larvae, and thus disposing of large numbers of this species in its earlier stages. In addition to the *agbo* pot, apparently its most prolific source, *C. nebulosa* has been bred from samples obtained from the following :—catchpits (for collecting household sullage), drains, water-pots, barrels, tins, a lawn-mower, roof-gutters, wells, pools, crab-holes, canoes, dung-emulsion (for smearing floors), tanning extract, starch emulsion, bottles of palm-wine, and tree-holes. It will be noticed that several of these are of the nature of fluids rich in organic matter, in which, as in *agbo* particularly, the Psychodid, *Pericoma meridionalis*, Eaton, is its extremely abundant and almost constant associate. It may be added that *C. nebulosa* is by no means uncommon in pools away from dwellings, often in association with *O. irritans* and *A. costalis*, so that domesticity, though a prominent feature of its bionomics in Lagos, is not an essential characteristic.

Mosquitos breeding in Roof-gutters.

Previous to their gradual removal after installation of a pipe-borne water-supply, roof-gutters were fairly regularly inspected and swept. Comparatively few samples have been examined, with the following record :—

TABLE VI.

Species of Mosquito.	Number of Occasions.	Percentage.
Stegomyia fasciata	13	56·5
,, *luteocephala*	4	17·4
Ochlerotatus irritans	2	
Culiciomyia nebulosa	2	26·1
Anopheles costalis	1	
,, *mauritianus*	1	

The occurrence of the larvae of *A. mauritianus*, Grandpré, is unique in the present record. It is a very rare mosquito in Lagos, but the adults have been found at least once in the same locality, viz., the dwellings around the Golf-course. The larvae have previously been obtained at Yaba (which is within the municipal area) in a pond near the Research Institute, and in road puddles in the wet season.

Mosquitos from various Domestic Sources.

The weekly visit of the Sanitary Inspector has made it possible to obtain samples of mosquito larvae from domestic sources, and these have been collected whenever circumstances permitted of their examination at the Research Institute with a view to determination of the species. The following record is the result of material thus brought under observation during an aggregate of 45 months, between the years 1914 and 1918, thus :—1914, May to November, 7 months ; 1915, 12 months ; 1916, January to April, and November to December, 6 months ; 1917, 12 months ; 1918 January to August, 8 months. Amongst domestic receptacles are included for the present purpose, besides the usual utensils such as water or *agbo* pots, tins, bottles, tanks, barrels, etc., the following :—wells on the premises, roof-gutters, house-drains and catch-pits, but not puddles in the yard or crab-holes.

No less than 17 species are represented, while the total number of species captured in Lagos during the period of the present record is 46. It may also be accepted that a collection under similar circumstances in any large coast town in West Africa will furnish a like preponderance of *S. fasciata* in greater or less degree ; *e.g.*, in Bathurst (date ?) with a collection obtained from 150 compounds each month, the proportions were *Stegomyia* 94 per cent., *Culex* 5·5 per cent., *Anopheles* 0·5 per cent.

During two years in Accra, 1,121 domestic samples examined gave the following result (Ingram, Bull. Ent. Res. x, 1919, pp. 50–51) :—

S. fasciata	occurred in	876	or 78·0 per cent.
C. fatigans	,, ,,	221	,, 19·7 ,,
A. costalis	,, ,,	43	,, 3·0 ,,
C. decens	,, ,,	20	,, 1·7 ,,
C. invidiosus	,, ,,	18	,, 1·6 ,,
C. duttoni	,, ,,	5	,, 0·4 ,,
C. tigripes var. *fuscus*		3	,, 0·2 ,,
C. nebulosa	,, ,,	1	,, 0·08 ,,

A collection in Lagos similar to the present one, composed of 1,043 samples and covering 8 months in 1910–1911, was recorded by Graham (Bull. Ent. Res. ii, p. 127) as below :—

S. fasciata	in	92·5	per cent.	of	domestic	water-samples	examined.
*Pectinopalpus fuscus**	,,	21·6	,,	,,	,,	,,	,,
C. duttoni	,,	8·3	,,	,,	,,	,,	,,
C. tigripes var. *fuscus*	,,	5·3	,,	,,	,,	,,	,,
C. nigrocostalis *	,,	1·8	,,	,,	,,	,,	,,
Pyretophorus costalis	,,	1·8	,,	,,	,,	,,	,,

* *Pectinopalpus fuscus*, Theo.=*Culiciomyia nebulosa*, Theo. ; and *Culex nigrocostalis* Theo.=*Culex decens*, Theo.

Table VII.

Mosquitos bred from Larvae obtained from Domestic Receptacles in Lagos, May 1914 to August 1918.

Species.	1914.		1915.		1916.		1917.		1918.		Total.	%
	Times found.	%	Times found.	%	Times found.	%	Times found.	%	Times found.	%		
S. fasciata	812	72·0	662	76·1	72	53	428	58	76	55·9	2050	68·17
Culic. nebulosa ..	234	20·7	149	17·1	59	43·3	276	37·5	55	40·4	773	25·70
A. costalis	38	3·4	18	2·1	0	—	16	3·2	2	1·5	74	2·46
C. decens	10	·9	12	1·4	1	·7	13	1·8	2	1·5	38	1·26
O. irritans	13	1·1	12	1·4	0	—	1	·1	0	—	26	·86
C. tigripes	9	·8	2	·2	0	—	0	—	0	—	11	·37
C. duttoni	8	·7	2	·2	0	—	0	—	0	—	10	·33
C. fatigans	0	—	4	·5	2	1·5	1	·1	0	—	7	·23
C. grahami	1	·1	4	·5	1	·7	0	—	0	—	6	·20
S. luteocephala ..	0	—	2	·2	0	—	2	·3	0	—	4	·13
C. quiarti	2	·2	0	—	0	—	0	—	0	—	2	·06
C. insignis	0	—	1	·1	0	—	0	—	0	—	1	·03
C. ataeniatus	1	·1	0	—	0	—	0	—	0	—	1	·03
C. thalassius	0	—	0	—	1	·7	0	—	0	—	1	·03
S. africana	0	—	1	·1	0	—	0	—	0	—	1	·03
Eretmopodites quinquevittatus ..	0	—	1	·1	0	—	0	—	0	—	1	·03
A. mauritianus ..	0	—	0	—	0	—	0	—	1	·7	1	·03
Totals	1128	—	870	—	136	—	737	—	136	—	3007	—

In Lagos *C. nebulosa* is, next to *S. fasciata*, the species most common in domestic receptacles (greatly exceeding the latter in *agbo* pots), but in Accra *C. fatigans* apparently always takes second place. The latter seems to be a comparatively rare insect in Lagos. Apart from those bred from larvae, a few adults were captured in crab-holes in the Golf-course swamp in July 1914, and occasional specimens have been obtained in Government Quarters in the residential area. The larval sources in the period 1914 to 1918 were as follows:—Wells, 6 occasions; boat or canoe, 2; barrel, 1; total, 9. If a slight but constant degree of salinity is favourable to this species one would expect a greater prevalence. *O. irritans* is a very common mosquito in Lagos and probably prefers a breeding-place with an appreciable amount of chlorides. It seems to have a special proclivity towards crab-holes, but an equally common source is surface pools; it also occurs in wells, catch-pits, and various receptacles of domestic or public utility; roof-guttering, canoes, and banana-tree stumps have yielded occasional samples. Curiously enough *O. nigricephalus*, its common associate in crab-holes, does not appear to affect domestic receptacles, not even wells, yet the adult insect is commonly captured in houses.

Culex decens, which freely uses crab-holes as a breeding-place, is after *S. fasciata* the most common species in wells; other sources were surface pools, drains, pots, tubs, etc., and once each a tree-hole, *agbo* pot, and rain-water on a tarpaulin.

Culex tigripes, from the predaceous habit of its larvae, is rather a welcome assistant than otherwise, though its presence deranges one's estimate of other domestic species. It has been found in wells, pools, pots, and once in *agbo*.

Culex duttoni seems to be less common in Lagos town than at Ebute Metta on the mainland. Water-pots and wells, and once a canoe, were the only sources discovered, but it has been previously found at Yaba in dirty water in tubs, barrels and ponds.

Culex fatigans (see above).

Culex grahami has been bred from well samples, from surface pools and borrow-pits, and once from a water-barrel.

Stegomyia luteocephala has its chief habitat in trees. The only domestic source has been the roof-gutters (from which it has also been obtained in Accra); a crab-hole, a pool in a yard, and a telegraph-pole socket have furnished larvae on isolated occasions.

Culex guiarti was obtained on two occasions from water-pots; it has previously been found in a pond at Yaba.

Culex insignis occurred once in a yard well; crab-holes and surface pools are usual sources.

Culex ataeniatus was obtained once only, from a household pot.

Culex thalassius was obtained once from a water-bucket; away from dwelling-houses its sources are numerous, viz., pools and brackish swamps, crab-holes, canoes, and once it was found in a railway girder.

S. africana was hatched on one occasion from a sample from a household tin; it has also been obtained from surface pools, and previously from a bamboo at Yaba.

Eretmopodites quinquevittatus was found abundantly on one occasion in a potsherd in a garden in the Hospital Compound.

Anopheles costalis takes a surprisingly high place amongst those obtained from household sources, especially as pools within the compound fence are excluded. In Lagos it can be reckoned upon to supply from 2 to 3 per cent. of the total finds in house to house inspection and generally takes third place numerically. Graham (*loc. cit.*), finding the average reaching 6·3 per cent. in February, a dry month, suggests that the reduction of puddles out of doors tends to a relative increase of *Anopheles* larvae in domestic receptacles. The present observations, however, are against this, as the finds of *A. costalis* here recorded occurred chiefly in the wet months. Thus out of 74 occasions, 52 occurred in the months June to September, and 64 in the months May to October, inclusive. In the year 1916, when no samples were examined in the months May to October, this species is entirely absent from the list. In the Accra list quoted above, *A. costalis* similarly takes third place amongst those obtained from domestic sources. Of domestic samples, wells contribute nearly half the number for this species in Lagos, viz., 35 out of 74. The water-pot filled at the well may thus receive the larvae, but there is little doubt that direct use is made of pots, tins, etc., within the house. On two occasions the larvae were found in *agbo* pots, and on six, in catch-pits ; drain, roof-gutter, banana-tree stump, and even a coconut shell furnished occasional samples. In the present series none occurred in tanks and barrels which receive rain-water from roofs.

The larvae of *A. mauritianus* were found once only in the roof-gutter of a European's residence.

The electric cat-fish (*Malapterurus electricus*) is not infrequently kept in domestic water-pots by the people of Lagos, its presence being supposed to preserve the purity of the water. Although it tends to act as a deterrent to the sanitary inspector, and therefore to neglect of cleansing the utensils, it certainly feeds on mosquito larvae, as was proved by experiment at the Research Institute at Yaba.

Collections of Adult Mosquitos.

The native sanitary inspector, whose task is the thorough and regular inspection of a daily block of compounds, is not a suitable person to rely on for collection of mosquitos in native houses, unless this duty is allotted to a definite individual relieved of other duties for the time. Although considerable numbers have been obtained and identified at one time or another, they have usually been collected either by the medical officer of health himself or by the European sanitary inspector, and few of these collections have been representative of the native town. Relative frequency of different species is greatly affected by locality and time of year. Thus in some low-lying streets in Lagos town a collection taken in the rains would certainly contain an overwhelming proportion of *A. costalis*. On one occasion a collection made by a sanitary student resident in Ebute Metta (on the mainland) consisted almost entirely of *Mansonioides africanus*, which is a rarity in Lagos town proper.

Attempts were occasionally made to interest the members of the class of sanitary students in training to collect adult mosquitos in the premises where they lodged, and cyanide tubes were issued for the purpose. The results were below expectation and the youths soon tired of the good work. The following, however, gives the result of one such effort representing native houses in different parts of the native town.

(As the main object of the collection was to ascertain the relative prevalence of *S. fasciata*, Anophelines are excluded, their numbers being always excessive during the period covered; two specimens of *A. nili* occurred amongst several hundreds of *A. costalis*).

TABLE VIII.

Adult Culicine Mosquitos in Native Houses, Lagos, July to September 1917.

Species.	No. of Specimens obtained.	Percentage.
Culiciomyia nebulosa	83	74·8
Ochlerotatus nigricephalus	10	9·0
Culex decens	5	4·5
„ *grahami*	3	2·7
Ochlerotatus irritans	3	2·7
Stegomyia fasciata	3	2·7
Culex tigripes	2	1·8
„ *thalassius*	2	1·8
Total	111	

This list might be regarded as corroborating the remarks above on the influence of the *agbo* pot, and of the sanitary inspector, on the preponderance of *Culiciomyia* over *Stegomyia*, were it not that Ingram and Macfie warn us against accepting such a collection (probably made chiefly in the evening) as evidence of the relative absence of *S. fasciata*, a scarcity which is often demonstrable even in blocks where its larvae are predominant, and for which a possible explanation is that this species "whilst entering houses to obtain a feed of blood, does not roost indoors" (Bull. Ent. Res. vii, p. 173). More abundant collections under proper conditions of observation should settle this point, but material of this nature from Lagos is at present insufficient. There seems no doubt that under native social conditions in Lagos *C. nebulosa* has become a highly domesticated species, and this habit along with its actual abundance suggests the need for a study of its bionomics and potentialities as a possible carrier of disease.

Many mosquitos have been captured for identification at various times in the European quarters to the east of the Race-course and around the Golf-course. The following list (p. 268) shows one such classified collection, in which note was taken of the numbers obtained during one month only; in a total of 1,682 specimens a rich mosquito fauna is represented including 26 species.

June is the month of greatest rainfall and *A. costalis* preponderates. Much has been done since then in the area in question in the way of filling hollows and draining. The abundance of crab-holes in the locality no doubt influences the order of precedence amongst the Culicines. *O. domesticus* takes a comparatively high place, though its larvae have only once been discovered in a neighbouring swamp; they have previously been found in borrow-pits by the railway on the mainland.

A smaller collection of 150 mosquitos from the same houses, covering the period 15th May to 21st July, 1917, is shown overleaf; 16 species are represented.

TABLE IX.

Adult Mosquitos captured in European Quarters, June 1914.

Species.	No. of Specimens obtained.	Percentage of Culicines.
Ochlerotatus irritans	112	26·23
„ *nigricephalus*	70	16·39
Culiciomyia nebulosa	53	12·41
Culex thalassius	45	10·54
Ochlerotatus domesticus	25	5·85
Culex decens	23	5·38
Stegomyia fasciata	13	3·04
Mansonioides africanus	10	2·34
Culex consimilis	9	2·11
Ochlerotatus cumminsi	8	1·88
Culex fatigans	7	1·64
Uranotaenia annulata	7	1·64
Culex grahami	6	1·40
„ *tigripes*	5	1·16
Banksinella punctocostalis	5	1·16
Culex duttoni	4	·93
„ *quasigelidus*	2	·47
Ochlerotatus caliginosus	2	·47
„ *argenteopunctatus*	1	·23
„ *punctothoracis*	1	·23
Culex salisburiensis	1	·23
Taeniorhynchus annetti	1	·23
„ *aurites*	1	·23
Others undetermined	16	3·75
Total Culicines	427	
Anopheles costalis	1251	Culicines 25·4 %
„ *nili*	3	Anophelines 74·6 %
„ *mauritianus*	1	
Total Anophelines	1,255	
Total Mosquitos	1,682	

TABLE X.

Species.	No. of Specimens obtained.	Percentage.
Ochlerotatus irritans	50	33·0
„ *nigricephalus*	30	20·0
Culiciomyia nebulosa	22	14·7
Culex decens	16	10·7
Anopheles costalis	9	6·0
Ochlerotatus domesticus	4	2·7
Culex grahami	4	2·7
„ *insignis*	4	2·7
„ *rima*	3	2·0
Taeniorhynchus aurites	2	1·3
Culex thalassius	1	each 0·7
„ *duttoni*	1	each 0·7
„ *pruina*	1	each 0·7
Stegomyia fasciata	1	each 0·7
„ *luteocephala*	1	each 0·7
Anopheles nili	1	each 0·7
Total	150	

The following species obtained in this locality on other occasions may be added to the above lists, viz.:—*Hodgesia sanguinis*, Theo., *O. ochraceus*, Theo., *C. univittatus*, Theo., *Mansonioides uniformis*, Theo., *Taeniorhynchus metallicus*, Theo., *Uranotaenia balfouri*, Theo., *U. bilineata*, Theo., var. *fraseri*, Theo. The last-named was at one period fairly abundant in the neighbourhood of Government House, but the others are of rare occurrence.

On 31st August 1915, a strong tornado from N.E. occurred about 6 p.m., in the course of which very numerous mosquitos were blown into the quarters occupied by the Medical Officer of Health. An examination of 36 specimens captured for identification gave the following curious result:—*Culex decens*, 33 ♀, 1 ♂; *Culex rima*, 1 ♀; *M. africanus*, 1 ♀.

There is here a lack of correspondence with the record of mosquitos taken in the same rooms during the immediately preceding 3 months, which is as follows:—403 mosquitos comprising *A. costalis*, 375 or 93 per cent.; *O. nigricephalus*, 8; *C. nebulosa*, 6; *C. thalassius*, 3; *C. decens*, 2; *O. irritans*, 2; *O. domesticus*, 2; *S. fasciata*, 2; *C. quasigelidus*, 1; *M. africanus*, 1; *T. metallicus*, 1.

It is probable that on this occasion some particular nidus close at hand was stirred up. A search further off in the Ikoyi Plains to windward of the populated area, where there are swamps and small surface pools, crab-holes, etc., as well as a few out-lying hamlets, revealed chiefly *A. costalis*, *O. irritans*, *U. annulata*, and *M. africanus*.

The numerous breeding places on the island beyond the limits of the inhabited town, and again the mangrove and brackish swamps beyond the island itself across the creeks to south and east, are doubtless capable of furnishing Lagos, at least intermittently, with wind-blown mosquitos, and possibly some species rarely found as larvae in the local sources may have their origin in these regions beyond.

In the period dealt with in these notes which may be taken as from May 1914 to August 1918, the number of different species which have come to notice in Lagos Municipal Area has been 46,† viz.:—

ANOPHELINAE.

Anopheles costalis, Theo., *A. funestus*, Giles, *A. mauritianus*, Grandpré, *A. obscurus*, Grünb.,* *A. nili*, Theo.*

CULICINAE.

Banksinella punctocostalis, Theo.*

Culex ataeniatus, Theo., *C. consimilis*, Newst., *C. decens*, Theo., *C. duttoni*, Theo., *C. fatigans*, Wied., *C. grahami*, Theo., *C. guiarti*, Blanch., *C. insignis*, Carter, *C. pruina*, Theo.,* *C. quasigelidus*, Theo.,* *C. rima*, Theo., *C. salisburiensis*, Theo., *C. sitiens*, Wied., *C. thalassius*, Theo., *C. tigripes*, Grandpré, *C. univittatus*, Theo.*

† To these 46 may be added 10 species absent from this list but included amongst the 41 species recorded from Lagos and published in the pamphlet of the Yellow Fever (West Africa) Commission, "Distribution of Mosquitoes in West Africa," Aug. 1913, viz. *Anopheles pharoënsis*, Theo., *Aëdomyia africana*, N.L., *Banksinella lineatopennis*, Ludl., *Eretmopodites inornatus*, Newst., *Mimomyia mimomyiaformis*, Newst., *Ochlerotatus longipalpis*, Grünb., *O. marshalli*, Theo., *Stegomyia apicoargentea*, Theo., *Toxorhynchites brevipalpis*, Theo., *Uranotaenia mashonaensis*, Theo.

Culiciomyia nebulosa, Theo.

Eretmopodites quinquevittatus, Theo.

Hodgesia sanguinis, Theo.*

Micraëdes inconspicuosus, Theo.

Mansonioides africanus, Theo., *M. uniformis*, Theo.*

Ochlerotatus apicoannulatus, Edw., *O. argenteopunctatus*, Theo.,* *O. caliginosus*, Grah.,* *O. cumminsi*, Theo.,* *O. domesticus*, Theo., *O. irritans*, Theo., *O. nigricephalus*, Theo., *O. ochraceus*, Theo.,* *O. punctothoracis*, Theo.*

Stegomyia africana, Theo., *S. fasciata*, F., *S. luteocephala*, Newst.

Taeniorhynchus annetti, Theo.,* *T. aurites*, Theo.,* *T. metallicus*, Theo.*

Uranotaenia annulata, Theo., *U. balfouri*, Theo.,* *U. bilineata*, Theo. var. *fraseri*.

(N.B.—Species marked with an asterisk have not been found in the larval state within the period dealt with in this paper, but the larvae of *C. quasigelidus*, *O. caliginosus*, *O. punctothoracis*, and *U. balfouri* have been recorded by Graham from borrow-pits at Yaba (Bull. Ent. Res. i, pp. 32, 39, 50). Breeding-places of the other species are referred to in the text.)

Of the 5 species of *Anopheles*, *A. costalis* is universally distributed over the island and is very abundant in the rains; it also makes an appreciable figure in the returns from domestic receptacles. Its eradication is one of the chief objectives of sanitary effort.

A. mauritianus is a rarity, but it has been bred from larvae in a roof-gutter and captured once or twice in European quarters; the larvae have also been taken in a pond and in road puddles at Yaba on the mainland.

A. funestus was bred from slightly brackish water in a canoe.

A. obscurus was captured once in a native house, but has not been taken in the larval state.

A. nili is found now and then in European houses in the Golf-course and Race-course residential area, and in offices and native houses in the town. Its larvae have not been obtained, but no doubt have their origin in the stagnant waters which abound on the island. The imagines when found have always been in such very scanty numbers that its influence as a malaria carrier seems almost negligible at present. The circumstances which favour the prevalence of one species over another are, however, incompletely understood, and as these may conceivably alter in unexpected ways or in conditions beyond immediate control, it is well to bear its presence in mind, and to discover and deal with its sources. For similar reasons the above notes and record of species found in Lagos within recent years, even if little more than a bare recital of names, may at any time prove of interest and possibly of practical use to future workers.

SOME NEW INJURIOUS WEEVILS.

By Guy A. K. Marshall, C.M.G., D.Sc.

(Plate VII.)

Subfamily Brachyderinae.

Tanymecus destructor, sp. nov. (Pl. vii, fig. 5).

Colour piceous black; the head with dark brown scaling above, except for a line of pale scales bordering the eye, and with pale buff scales beneath; scaling of the prothorax brown or grey brown on the disk, an ill-defined dark brown stripe at the side, and grey or buff beneath; scaling on the elytra grey or brown, with a very ill-defined darker stripe between striae 2 and 5, usually vanishing at a short distance from the base, but often traceable to behind the middle in the form of spots.

♂♀. *Head* with shallow, confluent and longitudinally striolate punctation; the forehead at its narrowest not narrower than the base of the rostrum, and without any central fovea or carina; the eyes very short oval, moderately convex. *Rostrum* a little shorter than the head, gradually narrowed from base to apex, and the dorsal area more markedly so, so that both scrobes are visible at the same time directly from above for almost the whole length; the dorsal area flat, sculptured like the head, and with a mere trace of a carina on the anterior half, the apical margin only shallowly sinuate. *Antennae* with the scape reaching the hind margin of the eye; the funicle with joint 1 longer than 2, and 2 as long as 3+4; 3 to 7 subequal. *Prothorax* a little longer than broad (♂) or a little broader than long (♀), broadest at the middle, the sides rather strongly and regularly rounded; the apex and base of equal width and both slightly arcuate, the apical margin rather oblique in lateral view; the dorsum evenly convex and with fine confluent punctation throughout. *Scutellum* inconspicuous. *Elytra* subtruncate at the base, separately rounded at the apex, with very sloping shoulders and without any humeral angle, the sides gently rounded and markedly narrower in the ♂ than in the ♀, and without any posterior callus; the striae fine, shallow and shallowly punctate; the intervals even, almost flat and finely shagreened; the numerous short recumbent scale-like setae hardly distinguishable from the narrow true scales. *Legs* densely clothed with variegated scales and setae; the front femora thicker than the others, the two anterior pairs bearing long erect hairs beneath on the basal half in the ♂; the hind tarsi with joint 1 as long as 2+3, and 2 longer than 3.

Length, 6–8 mm.; breadth, 2–3 mm.

S. Rhodesia: Salisbury, 5,000 feet, xi–xii. 1894 (*G.A.K.M.*); Mazoe, 4,000 feet, xii. 1919 (*R. W. Jack*).

Described from 17 ♂ ♂ and 19 ♀ ♀.

Of the described South African species, this insect is most nearly allied to *T. inafectatus*, Fhs., which has similarly sloping shoulders, the scape reaching to the hind margin of the eye, and similar hind tarsi. On the other hand the latter is a larger insect (10–12 mm.), with the rostrum as long as the head; joint 2 of the

funicle is as long as 1, and longer than 2+3; the scales on the elytra are much smaller, etc.

This wingless terrestrial species is abundant in the Salisbury district, and according to Mr. Jack, Government Entomologist, Southern Rhodesia, the adults sometimes cause considerable damage to the maize crops by eating off the young plants as soon as they appear above ground. They also feed on the leaves of other crops, such as sweet potatoes.

Tanymecus agricola. sp. nov. (Pl. vii, fig. 6).

Colour black, variegated with greyish buff scaling and light and dark brown setae; the pronotum with three indistinct dark stripes; the elytra with several indefinite interrupted dark lines.

♂♀. *Head* with rather coarse longitudinally confluent punctation; the forehead not narrower than the base of the rostrum and without any central fovea or carina; the eyes almost circular and rather strongly convex. *Rostrum* as long as the head and parallel-sided, the apex asymmetrically emarginate in the middle, the right side of the angle being rounded and the left straight; the dorsal area parallel-sided, shallowly impressed in the middle, with a well-marked narrow median carina, the sculpturing like that of the head. *Antennae* with the scape elongate, reaching beyond the front margin of the prothorax; the funicle with the two basal joints equal, 2 equal to 3+4, and 3 to 7 subequal. *Prothorax* longer than broad in both sexes, gently rounded at the sides, broadest a little before the middle, and with a faint apical constriction; the apex slightly narrower than the base, and both margins very gently arcuate, the apical margin oblique at the sides; the dorsum evenly convex, with close confluent punctation throughout; the short broad recumbent setae pale on the areas of pale scaling and dark brown elsewhere. *Scutellum* elongate, with dense whitish scales. *Elytra* jointly sinuate at the base, with rounded humeral angles, parallel-sided from the shoulders to beyond the middle, and impressed on each side before the apex, which is jointly rounded; the striae rather deep, especially towards the apex, but partly hidden by the scaling towards the sides, the punctures large at the base and becoming smaller behind; the intervals not broader than the punctures on the disk, slightly convex and shagreened; the pale areas formed of short oval or almost circular scales, mixed with numerous pale short flat curved setae, the dark areas only with similar dark brown setae. *Legs* grey, the femora with an indistinct pale spot beyond the middle; the front femora slightly thicker than the others, the two anterior pairs in the ♂ clothed with long hairs beneath on the basal half; the hind tarsi with joint 1 as long as 2 + 3, and 2 equal to 3.

Length, 7–8 mm.; breadth, 2·2–2·8 mm.

S. Rhodesia: Gwelo, i. 1920 (*R. Lowe Thompson*).

Described from 2 ♂♂ and 2 ♀♀.

Although very similar in general facies to *T. destructor*, this species may readily be distinguished by its longer and parallel-sided rostrum, more convex eyes, much longer scape, broad scales, etc.

It has also been found feeding upon maize.

Subfamily Otiorrhynchinae.

Isaniris ater, sp. nov. (Pl. vii, fig. 1).

Colour uniform dull black, the elytra with a small spot formed of small elongate white scales near the base of the 5th row of punctures, and sometimes smaller ones on the 7th and 9th, also a lateral row of similar spots near the margin, and occasionally traces of another a little above it.

♂♀. *Head* with coarse shallow punctation and a deep median furrow, and sparsely set with short spatulate white setae; the eyes moderately convex, deepest in the middle. *Rostrum* broad, gradually dilated at the apex, which is deeply sinuate in the middle, the epistome not carinate on its posterior edge; the dorsal area broad, regularly widening to the apex, broadly impressed in front, almost flat in the basal half, and there coarsely punctate and with a broad smooth median carina, which is highest at the base; the basal incision gently curved; a longitudinal lateral ridge running from the scrobe to the eye. *Antennae* black, with recumbent pale setae; the scape not much curved, moderately slender and rather abruptly clavate; the funicle with joints 1 to 6 progressively diminishing, 7 as long as 4. *Prothorax* broader than long, strongly rounded at the sides, broadest at the middle, truncate at base and apex, the base being narrowly carinate and a little broader than the apex; the dorsum covered with large flattened contiguous granules mostly forming irregular pentagons, each with a setiferous puncture; laterally the granules become elongate and less defined. *Elytra* narrowly ovate in the ♂, much broader in the ♀, broadest not far from the base, each with about 18 rows of punctures running in pairs, but becoming rather irregular towards the sides and apex; the intervals between the pairs more regular than the intervening ones, no broader than the septa in the rows and becoming granulate on the apical third, each bearing a spaced row of short subrecumbent setae, which are longer and more erect on the apical area. *Legs* rather stout, clothed with coarse pale setae and sparse setiform white scales, the setae being much longer, denser and softer on the lower edge of all the tibiae in the ♂; the hind tibiae of the ♂ deeply excised on the inner edge for more than half their length from the apex, the excision flattened and smooth.

Length, 8–8·75 mm.; breadth, 3·2–4·2 mm.

S. Rhodesia: Salisbury, ix. 1893, etc. (*G.A.K.M.*—type). Nyasaland: Blantyre, iv–v. 1910 (*Dr. J. E. S. Old*).

The sculpturing of the pronotum will distinguish this insect from all the described species of *Isaniris*, except *I. acuticollis*, Fst., which differs in having the prothorax sharply angulate behind on each side and in lacking the granules on the elytra. In general form and structure it much more resembles such species of *Systates* as *S. brevicollis*, Fst., and *S. crenatipennis*, Frm., but these differ in having only 10 rows of punctures on the elytra, which Faust considered to be the only character separating *Systates* from *Isaniris*.

This weevil occurs very commonly on trees of the genus *Brachystegia*, which form the principal component of the woodland on the Mashonaland plateau; but Mr. R. W. Jack informs me that it is a very general feeder, attacking various cultivated plants, including citrus trees.

Systates exaptus, sp. nov. (Pl. vii, fig. 2).

Colour black, with brownish grey scaling, which is sufficiently thin on the pronotum and disk of the elytra for the shiny integument to show through, but is denser at the sides and especially on the declivity of the elytra; above the declivity an ill-defined common transverse dark chevron-shaped patch, the posterior edge of which is deeply sinuated.

♂♀. *Head* obsoletely punctate, the forehead with a short deep median furrow; the furrow separating it from the rostrum almost straight; the eyes strongly convex, deepest in the middle. *Rostrum* as long as broad (♀) or slightly longer than broad (♂), subparallel-sided in its basal half, then gradually dilated to the apex; the dorsal area alutaceous, shallowly impressed on each side of the sharp median carina, the lateral margins with shallow confluent punctures, very slightly costate, parallel in the basal half, then gradually diverging; the central carina broadly forked a little beyond the middle, the fork enclosing a large smooth subtriangular impressed area just behind the epistome; a low longitudinal ridge running from the scrobe to the eye. *Antennae* with the scape slender, cylindrical, abruptly clavate and clothed with recumbent white setae and narrow setiform scales; formula of funicle: 1, 2, (3, 7), (4, 5, 6). *Prothorax* broader than long, gently rounded at the sides, broadest at the middle; the apex truncate or shallowly sinuate, a little narrower than the base, which is feebly marginate; the dorsum closely set throughout with low contiguous shiny granules, each bearing a puncture containing an erect scale-like seta; laterally the granules are much reduced and interspersed towards the base with coarse shallow punctures. *Elytra* without any truncate margin at the base, very broadly ovate in the ♀, much narrower in the ♂, widest not far from the base, the shoulders broadly rounded, the posterior declivity steep in the ♂ and almost perpendicular in the ♀; the striae rather shallow, closely punctate, the punctures as broad as (♂) or narrower than (♀) the intervals, each of the latter bearing a single row of short erect flattened setae; the scales small, narrowly ovate, the palest ones broader. *Legs* with short pale setae and narrow scales; all the tibiae denticulate internally in both sexes, the hind pair in the ♂ broader, with the inner face flattened and smooth throughout and incurved at the apex, the lower edge deeply bisinuate and with an obtuse tooth a little before the middle; in the ♀ the hind tibia has a short smooth shallow hollow on the inner face near the apex. *Venter* of ♂ with two widely separated small tubercles near the posterior edge of the 1st segment.

Length, 6·5–7·5 mm.; breadth, 3–3·6 mm.

S. Rhodesia: Salisbury. i. 1895—ii. 1905 (*G.A.K.M.*—type); Umtali, xi. 1901 (*G.A.K.M.*); Mpudzi R., Umtali dist., xi. 1901 (*G.A.K.M.*); Mt. Chirinda, Melsetter dist., ii. 1907 (*C. F. M. Swynnerton*).

This common species appears to feed on a number of different herbaceous plants, and the adults have been observed by Mr. R. W. Jack to do appreciable injury to young maize plants.*

* The following closely allied species occurs on the coast in the same latitude:—*Systates beiranus*, sp. n.—Closely resembling *S. exaptus* in form and colouring, but smaller and differing in the following particulars: rostrum with the dorsal area slightly convex longitudinally in the basal half, the anterior impressed portion not triangular, but separated off by a low transverse ridge; no longitudinal ridge behind the scrobe; the epistome slightly asymmetrical, the apex of the curve formed by the delimiting carina being a little to the left of the median line, and the carina on the right side rather longer and higher than that on the left; the prothorax with a very low median costa in the anterior half; the hind tibiae of ♂ smooth and flattened internally, but less incurved at the apex and without any tooth on the lower edge; the elytra vertically truncate at the base; 1st ventrite without tubercles in ♂. *Length*, 5–6 mm.; breadth, 2·4–3 mm. Portuguese East Africa: Beira, x.1900—x.1904 (*P. A. Sheppard*); 3 ♂♂, 7 ♀♀.

Systates chirindensis, sp. nov.

♂♀. Dull black, uniformly and thinly clothed with very small grey or light brown scales, sometimes with a greenish reflection; in the ♀ only there is a large common triangular denuded dark patch at the top of the declivity with its apex directed backwards.

Head separated from the rostrum by a straight furrow, impunctate, and with a shallow median furrow that is longer than half the transverse one; the eyes moderately convex, deepest in the middle. *Rostrum* a little broader than long, very slightly narrowed from the base to the middle, then gradually widening to the apex; the dorsal area almost flat, finely alutaceous, parallel-sided to the middle and then dilated, the margins slightly costate and very shallowly punctate, the median carina low and broadly forked beyond the middle, the fork enclosing a shallowly impressed subtriangular smooth bare area; no costa behind the scrobe. *Antennae* long and very slender, clothed with sparse fine recumbent setae; the scape cylindrical, abruptly clavate; the relative lengths of the joints of the funicle thus: 1, 2, 3 (4, 5), (6, 7). *Prothorax* somewhat broader than long, moderately rounded at the sides, broadest a little before the middle, truncate at base and apex, the former not marginate and a little broader than the apex; the dorsum evenly set with low shiny granules, each with a setigerous puncture; laterally the granules are much reduced. *Elytra* very narrowly ovate in the ♂, much broader in the ♀, without any truncate margin at the base, the apices jointly rounded and produced downwards like a beak, especially in the ♀; the striae shallow and containing punctures that are deep towards the base but diminish much behind; the intervals broader than the punctures, slightly convex, each with a row of small low setigerous granules, the setae being longer and thinner in the ♀, and also duplicated on the declivity of interval 1 in that sex. *Legs* thinly clothed with narrow pale scales, the hind femora with a broad dark band in the middle; in the ♂, the front tibiae slightly bent inwards at two-thirds from the base and denticulate internally, the mid pair also denticulate and the lower edge very strongly curved in the apical half, the hind pair only slightly curved, the inner face broadly flattened and smooth almost to the base, with a single row of granules along its lower edge in the apical half and the upper edge granulate; in the ♀, the tibiae only slightly curved, the hind pair with a smooth flat area on the inner face bounded above and below with a row of granules. *Venter* with ventrite 1 in the ♂ very broadly impressed at the base and with two widely separated small conical tubercles on the hind margin.

Length, 6·4–8 mm.; breadth, 2·6–3·6 mm.

S. Rhodesia: Mount Chirinda, 4,000 ft., xii. 1901 and x. 1905 (*G.A.K.M.*). Described from 14 ♂♂ and 15 ♀♀.

From the very few species of *Systates* having granulated elytra, such as *S. granosus*, Fst., this insect may be distinguished by the absence of the vertically truncate edge at the base of the elytra.

In 1915, Mr. C. F. M. Swynnerton found the adults of this species feeding in numbers on the leaves of coffee bushes on Mt. Chirinda.

Subfamily Cryptorrhynchinae.

Genus **Elytroteinus,** nov. nom.

Pteroporus, Fairmaire (*nec* Schönh. 1843), Ann. Soc. Ent. France, 1881, p. 307.

To the generic characters given by Fairmaire the following may be added :— The mesosternum parallel-sided, much broader than one of the mid-coxae, the posterior edge of the cavity markedly overhanging ; the intercoxal process of the metasternum very broadly truncate, no metepisternal suture ; ventrite 2 in the middle much longer than 3 + 4 ; the elytra with stria 10 complete, and the lateral margin rather strongly sinuate at the base ; the front femora with a stout tooth, and all the femora very shallowly sulcate beneath ; the tibiae with a sharp carina on the dorsal edge ; the tarsal claws simple and divaricate.

Elytroteinus subtruncatus, Frm. (Pl. vii, fig. 8).

This is the only known species of the genus and was originally described from Fiji (*op. cit.* p. 308), but it has recently been found by Mr. O. H. Swezey at Honolulu attacking the roots of ginger (*Hedychium coronarium*).

Subfamily Calandrinae.

Calandra shoreae, sp. nov. (Pl. vii, fig. 4).

♂♀. Colour dull black or piceous, without scaling ; the rostrum, legs and antennae red-brown.

Head with three transverse rows of punctures behind the eyes, the forehead with an elongate fovea. *Rostrum* elongate, slightly curved, gradually widened at the apex, with four dorsal rows of punctures and three lateral ones on each side, of which the uppermost disappears in the basal half ; in the ♀ the rostrum is very little longer than that of the ♂ and the punctures are finer. *Antennae* with joints 3 to 5 of the funicle about as long as broad, the others longer. *Prothorax* a little longer than broad, widest near the base, the sides slightly rounded and gradually narrowed to the apical constriction ; the base slightly rounded in front of the scutellum and truncate on each side, the apex broadly sinuate ; the dorsum coarsely and closely punctate, the transverse septa between the punctures being narrower and lower than the longitudinal ones, producing the effect of numerous undulating longitudinal carinae ; the median carina well-marked, fairly straight, and running from the apical constriction almost to the base ; each puncture with a very short stout erect pale seta. *Elytra* with the usual sculpturing characteristic of the genus, intervals 1, 3, 5, 7 and 9 being rather higher and much broader than the others, and each with a row of punctures almost as large as the quadrate ones in the striae ; the posterior callus feeble, and intervals 3 and 9 not elevated at the apex. *Abdomen* with the exposed part of the pygidium forming almost an equilateral triangle, flat and coarsely scrobiculate.

Length, 3·2–4·4 mm. ; breadth, 1·2–1·8 mm.

India : Dehra Dun, United Provinces (*C. F. C. Beeson*) ; Kheri, U.P. (*Beeson*) ; Gorakpur, U.P. (*A. E. Osmaston*) ; Shwegu, Burma (*Beeson*) ; Pusa, Bengal ; Adoni, Bellary dist., Madras ; Pattikonda, Kurnul, Madras ; Waltair, Madras (*S. W. Kemp*) ; Nilgiri Hills (*H. L. Andrewes*). Mauritius (*J. E. M. Brown*).

Very closely allied to *Calandra sculpturata*, Gyl., from South and East Africa,* which has the pronotum somewhat similarly sculptured, but the longitudinal carination is not so well marked in the basal half and the median carina is less distinct in the African species; this also has a small spot composed of a few pale scales in the middle of the base of the pronotum, and another on the shoulder of each elytron; and the exposed part of the pygidium is more elongate and transversely convex. *C. shoreae* attacks the seeds of the sal tree (*Shorea robusta*), as well as those of *Dipterocarpus turbinatus*.

Prof. A. Hustache had already drawn up an M.S. description of this species upon two specimens from Mauritius, but he has kindly suggested that the present description should be published instead.

Calandra glandium, sp. nov. (Pl. vii, fig. 3).

Closely allied to the foregoing species, and differing principally in the following characters:—A rather larger insect and longer in proportion to its breadth; rostrum of the ♀ finely aciculate, rather dull, and as strongly punctate as that of the ♂ of *C. shoreae*; the rostrum of the ♂ much shorter and straighter, rugosely punctate and with four dorsal rows of minute granules; the pronotum with large reticulate punctures, all the interspaces being equally raised and the median carina usually indefinite and abbreviated; the elytra longer in proportion, the posterior callus more developed and intervals 3 and 9 elevated at the apex, so that the apical junction of striae 3 and 8 lies in a deep impression; the rugose area of the pygidium more elongate and with a sharp median longitudinal carina.

Length, 4·6–5·2 mm.; breadth, 1·6–1·8 mm.

India: W. Almora, Kumaon, numerous specimens bred from acorns of *Quercus incana* (*H. G. Champion*—type); Naini Tal, Kumaon, bred from acorns of *Quercus dilatata* (*E. Marsden*).

Stenommatus musae, sp. nov. (Pl. vii, fig. 7).

Colour dull piceous black, usually with a greyish sheen; the antennae, legs and apical portion of the rostrum red-brown.

Head short globular, smooth, rather shiny, with minute sparse punctures; the eyes actually contiguous beneath. *Rostrum* (♀) elongate, as long as the head and prothorax together, slightly curved, moderately stout, almost cylindrical but somewhat flattened beneath, not dilated at the apex, opaque and with small close shallow punctures for four-fifths of its length, the apical fifth impunctate and very shiny; a deep lanceolate median furrow from the base to the antennae; the lower surface impunctate, with a low shiny median carina; colour red-brown, with only the basal third or fourth part blackish; in the ♂, a little shorter and broader proportionately, and blackish from the base to the middle or beyond. *Antennae* with

* Schönherr records this species from Bengal, but his description agrees well with a South African species. Prof. Aurivillius has kindly confirmed the identification on comparing one of my African specimens with the type of *C. sculpturata*, which, he informs me, bears the label "Cap. B. spei ? Drège." The Indian record seems almost certainly erroneous. Drège resided in South Africa, and all the other species described from his collection by Schönherr are from that country.

the scape short, just reaching the eye. *Prothorax* a little longer than broad, the sides subparallel from the base to beyond the middle, then roundly narrowed and very deeply constricted near the apex, the constriction continued across the dorsum as a deep curved furrow; the apical margin truncate or very slightly sinuate, the base truncate; the dorsum gently convex transversely and evenly set throughout with small separated punctures, the interspaces being as broad as the punctures themselves; on the sides the punctures are rather larger and much closer together. *Elytra* elongate-ovate, slightly sinuate jointly at the base, and without any humeral prominence; the sides gently curved, broadest at a short distance from the base, then rather rapidly narrowing to the apex, which is broadly rounded; the striae containing rows of shallow distant punctures, which encroach slightly on the sides of the convex impunctate intervals.

Length, 1·6–1·8 mm.; breadth, 0·6–0·7 mm.

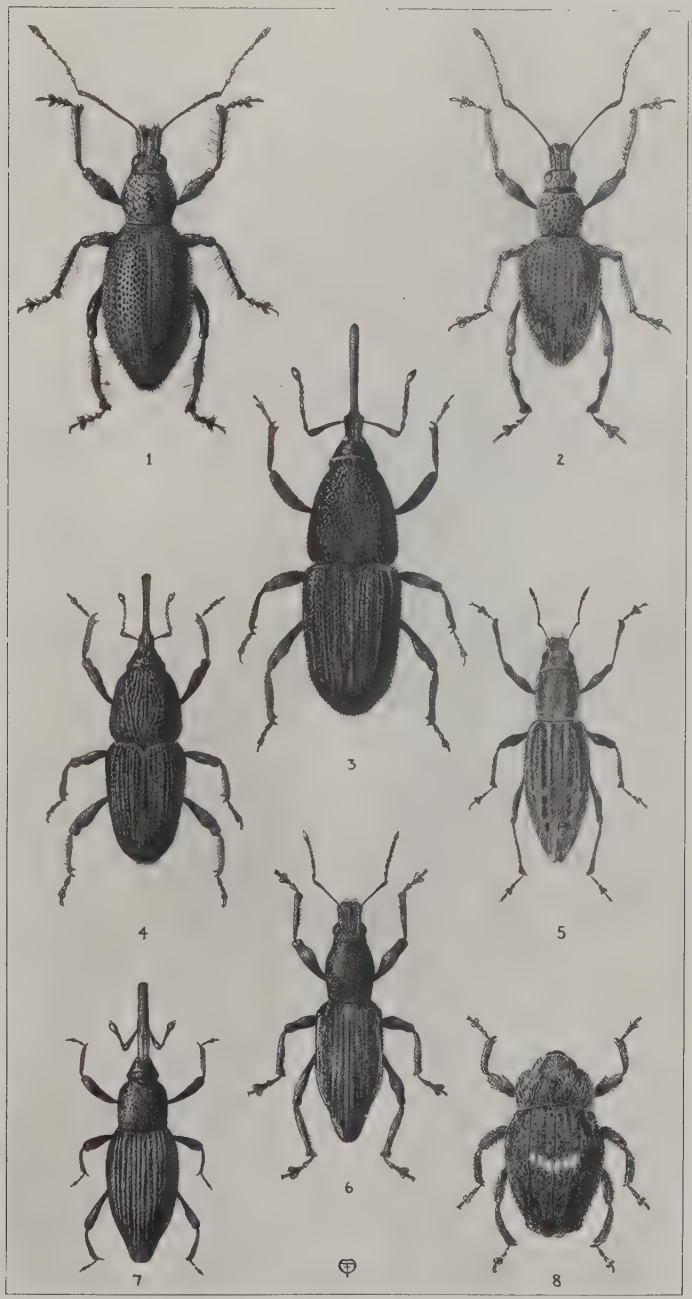
Hawaian Is.: 2 ♂ ♂, 8 ♀ ♀, Kaimuki, Oahu, 19.ii.1920 (*O. H. Swezey*).

The genotype, *S. fryi*, Woll., from Mexico, differs in its slightly larger size; the scape extends behind the eye; the eyes are not quite confluent beneath; the head is opaque and coarsely punctate; the rostrum is markedly shorter; the prothorax is broader and much more coarsely punctate, the interspaces being much narrower than the punctures, etc.

This species was found by Mr. Swezey breeding in numbers in the root (corm) of a banana plant.

EXPLANATION OF PLATE VII.

Fig. 1. *Isaniris ater*, sp. n., ♂.
2. *Systates exaptus*, sp. n., ♂.
3. *Calandra glandium*, sp. n., ♀.
4. „ *shoreae*, sp. n., ♀.
5. *Tanymecus destructor*, sp. n., ♀.
6. „ *agricola*, sp. n., ♂.
7. *Stenommatus musae*, sp. n.
8. *Elytroteinus subtruncatus*, Frm.



INJURIOUS CURCULIONIDÆ.

THE HABITS OF A DIPTERON PREDACEOUS ON MOSQUITOS IN NYASALAND.

By W. A. Lamborn, M.R.C.S., L.R.C.P.

On 12th September 1919, while watching at a pool near Kotakota, Lake Nyasa, the emergence of mosquitos from their pupae, which in the case of this particular species takes place mostly between 4.30 p.m. and dusk (about 6.30 at that time of year), the writer saw at rest on some scum on the surface of the water, an Anthomyiid fly of the genus *Lispa*, which after a few minutes made a sudden rush at a mosquito just emerging from its pupa-case. The mosquito with its wings still unexpanded and part of its legs and the hinder segments of its abdomen still within the pupa-case was absolutely at its mercy. The fly grappling it from behind with its front legs proceeded to thrust its proboscis into the thorax. The fly was by no means timid, and it was possible to lean over and approach one's head to watch the proceedings so closely that it was even possible to determine by its antennae the sex of the unlucky mosquito; it was a male. The fly was captured before it had finished its meal, lest it should suddenly fly up and escape.

Next morning the pool was again visited and quite a number of the same flies were observed on the scum. One was seen to make a sudden thrust with its proboscis into the water, at the edge of the scum, followed by a series of similar but smaller efforts, as if it had seized some body, though insecurely at first. Presently it raised itself and partly drew out of the water a mosquito larva, about half-grown, impaled on its proboscis, which it proceeded to suck. The larva was not seen to move, possibly being paralysed by some buccal secretion from the fly. Advantage was taken of the fly's lack of timidity to push beneath the scum a broad stick on which it and its victim were gradually raised, so that the feeding process could be studied as near at hand as one wished. A good series of the flies, subsequently taken, were all removed in this manner, the stick being thrust into the mouth of a net which was then closed.

One fly was seen on the same occasion to grasp and thrust its proboscis into a mosquito, a female, which had failed to emerge completely from its pupa and may or may not have been dead at the time; it was not seen to move at all. The rest of the series were all seen at one time or another attacking mosquito larvae, not always with success, but when successful dragging them out of the water and sucking their juices.

On 13th September, the emergence of a *Culex* was witnessed almost from the first; the thorax bursting its covering, the imago then extracting its head, the rest of the body following until the wings and some of the legs were free. At this point a *Lispa*, which had been resting about four inches off on some scum, approached deliberately on the surface film, grasped the still soft *Culex* with its forelegs, and thrust its proboscis into the thorax, dragging the mosquito beneath its body to a little piece of leaf, about two inches off, floating on the water. As the captor walked, one could see quite clearly the legs of the victim trailing beneath. The fly with its prey was then taken. The mosquito, a female, was still alive and moved its legs feebly.

The attack of another *Lispa* in a similar way on a mosquito pupa was witnessed on the same occasion. The pupa impaled on the fly's proboscis, was drawn from the water, fully extended, to a little bit of leaf on which the fly had been sitting. It was not seen to move, so that one is unable to assert that it was living when seized by the fly.

At a later date many instances were witnessed of attacks by the flies on mosquitos which had been unable to fly away on the previous night owing to the failure of their wings to expand properly. One fly had impaled in the usual way a helpless mosquito, and had dragged it on to a small stick in the water. On an attempt being made to secure it, the insect flew across the water bearing its prey to another support, a foot further off in the water. Threatened by another attempt it flew up bearing its prey and settled fully another foot away on a blade of grass where both were captured. Its prey, a female mosquito, moved freely after capture. The manoeuvres of another fly were precisely the same when it was menaced with the net. In view of the unsuspicious attitude of most of the flies previously captured, this wariness was a little surprising, more especially as they were taken, with the water still in the shade, at an early hour when most insects of diurnal habits are prone to be sluggish in their perceptive faculties.

The pressure of other work made it impossible to study the behaviour of at least four other Diptera, all having business on the water. One species appeared to act as a scavenger, endeavouring to extract nourishment out of empty pupa-cases and larval skins of mosquitos. Another small species, which was not captured, was almost certainly predaceous on mosquito larvae. It gave from time to time most careful and deliberate attention to the cleaning of its long, pointed proboscis, after which it gradually stalked the smaller mosquito larvae breathing at the surface film, endeavouring, seemingly, to thrust its proboscis into their air-tubes, and repeating this action again and again, though in no instance was a successful issue witnessed.

In the same pool in which these *Culex* larvae occurred in swarms were a few predaceous larvae of a much larger species of mosquito, which every now and again attempted to secure one of the *Culex* larvae, causing them instantly to scatter. On the far side of the pool, which was about two feet across, was noticed a " rat-tailed " larva struggling on the surface, and on near approach it was seen that one of the larger species of mosquito larvae, almost fully grown, had seized it firmly at the point of junction of the " tail " with the body. The rat-tailed larva wriggled and contorted itself in every possible way ; its tail became twisted round the head of its adversary at least twice ; and it endeavoured to escape by diving into the depths of the pool, but unsuccessfully. The mosquito larva never slackened hold and, when its victim approached the surface, immediately put up its respiratory siphon and probably nibbled away constantly, for by and by a portion of the cuticle of the larva was seen to be partly detached near the mouth of its assailant and to be trailing the water. Towards the end of a prolonged and desperate struggle a second similar mosquito larva joined in the attack, seizing the Syrphid larva at a point midway between the two extremities of its body. The Syrphid struggled still more violently. Its new assailant, better situated for attack at a vital spot

than the original one, very soon bit a hole through which more and more of the Syrphid's viscera gradually protruded. Eventually this mosquito larva dropped off and wriggled away, taking a small portion with it, much of which was consumed at leisure. The Syrphid's struggles thereafter got more and more feeble and in two or three minutes it straightened out and ceased to move, floating on the surface, the first mosquito larva still holding to it. An attempt was then made to secure this larva, which however alarmed by the movements of the numerous *Culex* larvae through the water being disturbed by the net, suddenly let go and vanished. The precise species of larva is therefore impossible of determination; all that can be recorded in referrence to it is that it was considerably larger than any of the *Culex* larvae; it had posterior respiratory spiracles only; it also suspended itself in the water rather more obliquely than the *Culex* larvae did.* It was not possible to capture any with the means at one's disposal.

Such a fate for these Syrphid larvae would seem to be by no means uncommon, for on the following morning two more, both dead and with viscera protruding, were seen floating on the surface. One rather wondered how it was that any of the Syrphid larvae, which were securely grouped on a piece of rotting cassava one and a half inches below with their tubes thrust up to the surface, ever came up to the top, thereby incurring such risks. The explanation is probably to be found in the occasional failure of the larvae to withdraw their life-lines from the surface in sufficient time to escape the sudden attack of the mosquito larvae and in their subsequent endeavours to set themselves free.

When the sun was off the pool full-fed Syrphid larvae, with their tails already partly shrivelled, were seen to crawl out and to burrow in dry sand well above waterline, where their puparia were readily obtained. Some of these larvae placed on 12th September in a box containing dry sand pupated in about forty-eight hours, and the flies emerged on about 23rd September, the pupal stage having therefore occupied about twelve days. The species has been identified by the Imperial Bureau of Entomology as *Phytomia curta*, Lw. During the heat of the day these flies were frequently seen ovipositing in the wet sand at the margin of the pool.

[The fact that *Lispa* preys on mosquito larvae has also been recorded by Mr. J. Mitford Atkinson (Jl. Trop. Med. xii, 1909, pp. 255-6; Howard, Dyar & Knab, Mosquitoes of N. America, i, 1912, p. 170), who in Hong Kong observed *Lispa sinensis*, Schiner, devouring larvae almost as long as their own bodies.—Ed.]

* [The predaceous larvae were probably either *Toxorhynchites brevipalpis*, Theo., or *Culex tigripes*, Grp., both of which are known to prey on other mosquito larvae.—Ed.]

A NEW TYPE OF ENTOMOLOGICAL KILLING-BOTTLE.

By Malcolm E. MacGregor,

Wellcome Field Laboratory, Surrey, Wellcome Bureau of Scientific Research.

The "cyanide bottle" is never a very attractive part of the entomologist's equipment. When made up in the old way, *i.e.*, plaster of Paris poured over lumps of solid potassium cyanide and the plaster then allowed to set, the contrivance has an attractive appearance, but is an abomination to use, especially if small insects are being dealt with. The large amount of water utilised in making up the plaster of Paris can never be dried out properly, and the potassium cyanide being deliquescent to some extent the presence of moisture is unavoidable. Moreover the cyanide soon decomposes and turns brown, imparting its colour to the plaster and forming an ugly-looking mass on which small insects are not contrasted and may be easily overlooked and lost.

The newer method of making up the killing-bottle by powdering the cyanide and mixing this with about an equal weight of powdered borax, compressing the mass at the bottom of the bottle, and afterwards pouring over it a small amount of plaster just sufficient to secure the powders, is a distinct improvement in so far as the approach to anhydrous conditions is concerned and the more rapid liberation of HCN gas. However, the mass decomposes more rapidly with the addition of the borax, and the unfortunate brown coloration is accentuated.

There are too the methods that depend on fixing the potassium cyanide in the cork instead of in the bottle, which are certainly improvements in that the insects are left lying on the glass, against which they can be easily seen; but with this method the cyanide is not in a very safe situation, and furthermore cannot so rapidly evolve as much HCN gas as cyanide that is distributed over the bottom of the bottle.

In addition to the faults peculiar to whatever method is employed in making up the cyanide killing-bottle there are the following disadvantages in the use of cyanide:—(1) the bottle is a potential danger to the ignorant if not properly looked after, owing to the highly poisonous nature of potassium cyanide; (2) if the bottle is accidentally broken, cases of poisoning may result unless every scrap of the cyanide and plaster is collected and destroyed; (3) the killing power of the preparation speedily weakens if the bottle is constantly used; (4) insects recover more often from HCN gas in weak concentration than they do from concentrated chloroform vapour; (5) when the cyanide bottle is exhausted it is preferable to throw the whole thing away (unless the bottle is of the type where the cyanide is secured in the cork) rather than to attempt to chip out the hard plaster to renew the apparatus, and a new killing bottle has therefore to be obtained.

On the strength of these objections I have for several years preferred to use chloroform as an insect poison, utilising chloroform-saturated rubber in place of cyanide. The method is ideal as far as its action is concerned, but the one great drawback has been the rapid evaporation of the chloroform and the constant addition of the fluid that has been necessary.

In order to have a killing-bottle which will have the great advantage of chloroform as the poison, the bottle described below is now used. It can be made from ordinary laboratory material, unless a very large-mouthed bottle is required.

Select an ordinary " boiling-tube " (large form of test-tube), and a large rubber cork which will just slide down the inside of the tube, making rather a tight fit. Bore a hole in the centre of the cork so that a small piece of glass-tubing (internal diameter, 2 to 3 mm.) can be forced through. The glass-tubing should be of such a size that it projects about $\frac{3}{4}$ inch on one side of the cork, and about $\frac{1}{4}$ inch on the other.

Now slide the cork into the boiling-tube so that the $\frac{3}{4}$ inch length of glass tubing projects towards the bottom of the boiling-tube, and force it down until the end of the tubing touches the bottom of the tube. If the rubber cork is a tight fit

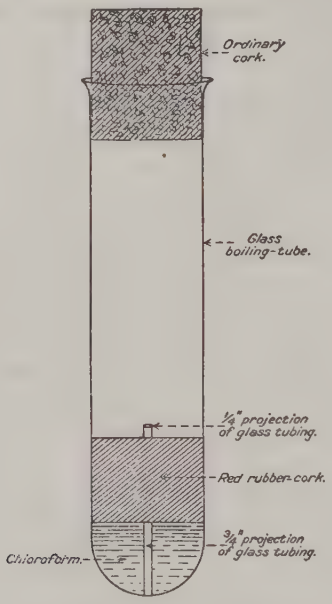


Fig. 1. A chloroform killing-bottle.

(as it should be) moisten the cork slightly with water and press it down the boiling-tube by the aid of the open end of a small test-tube. Warm the apparatus so as to drive off any moisture that may remain, and when dry it may be charged with chloroform. This is accomplished as follows :—Pour into the boiling-tube sufficient chloroform to stand about 2 inches above the upper surface of the rubber cork, and then carefully warm the air-space below the cork over a spirit-lamp. The air will be partly driven out by expansion. Remove the tube from the flame and as the space cools the chloroform will run in to fill the partial vacuum. Then again heat the bottom of the tube until the chloroform within boils gently, and all the air is driven out by the chloroform vapour. On cooling once more the space will this time be completely filled with chloroform. Now invert the tube and

pour out the surplus chloroform from the upper surface of the cork. None of the chloroform in the space below will escape, owing to the air pressure at the upper open end of the glass tubing. Gently warm the sides of the tube above the cork to drive off any remnants of liquid chloroform, and when an ordinary cork has been fitted, we have an apparatus similar to that shown in fig. 1.

Although pure rubber is soluble in chloroform, it will be found that the compound from which the rubber corks (red variety) are made, swells when in contact with chloroform but will not dissolve.

The following are the advantages of the apparatus :—(1) A high concentration of chloroform vapour is always available ; (2) if the tube is accidentally broken there is no danger of poisoning ; (3) 5 cc. of chloroform is sufficient for a week's continuous use, and the tube is therefore exceedingly economical.

Care should, however, be taken that the lower end of the tube containing the chloroform be not unduly heated by the hand, otherwise gaseous pressure will force the liquid up the central glass tubing. Should this occur at any time it is only necessary to shake out the few drops of liquid at the upper end of the cork, and blow into the tube to dry the cork surface. If the tube is inverted, no amount of overheating will do more harm than to dissipate the chloroform to some extent, and for this reason it should be carried in this position. The open lower end of the glass tubing then stands above the surface of the liquid chloroform, and the apparatus is " sealed."

INSECT PESTS OF DATES AND THE DATE PALM IN MESOPOTAMIA AND ELSEWHERE.

By P. A. Buxton, M.A., F.E.S.,

Fellow of Trinity College, Cambridge; formerly Entomologist, Mesopotamian Expeditionary Force.

(Plate VIII).

In the summer of 1918, there was every prospect of an unusually good crop of dates in Mesopotamia, until the month of June, when a large number of the half-grown dates suddenly became "hashaf"—an Arabic word signifying that they dried up and fell from the trees. This was a very serious matter, not only because the date is the principal resource of the country, but also because any and every disaster was at that time attributed by a section of the population to the British administration. At the end of July I was lent to the Directorate of Agriculture to carry out an investigation upon the failure of the date crop. I found that the principal pest, the larva of a Gelechiid moth, had finished its work, and had wandered away from the palms to pupate; and though I was unable to solve the problem of its life-history, I had the good fortune to discover a good deal that was new about the insect pests of the date palm. At the time I published a report (1918), to which I only refer now in order to say that it was produced on the spot and without access to any books; it contains certain inaccuracies, and anything of value which I may have discovered will be found in the present paper. During the course of my investigations I visited all the important date-growing areas of Mesopotamia, that is to say, Baghdad and its neighbourhood, the Diyala River from Ba'qubah to the Persian Frontier at Baba Pillawi, Mendali and Balad Ruz, Basra and the country round it, Mohammerah and Fao, the Lower Euphrates from Nasiriyeh to Suq-ash-Shuyukh, Qurnah and Amara. At the time of my visit the fruit was nearly ripe, so that it was not difficult to learn the distinctions between the different varieties of date palms, a point of great importance in view of the fact that they are liable to the various pests in varying degrees. I strongly recommend future investigators to familiarize themselves thoroughly with these varieties, and also with the very considerable number of Arabic words which are used specially for the date palm and its cultivation. This is no small task, as will be realized when I mention that in Mesopotamia about 70 words are employed by the peasants for various parts of the date palm; the vocabulary relating to cultivation and methods of employment is just as extensive.

The literature relating to the pests of the date is so scattered, some of it in the most obscure periodicals, that I believe this paper will meet a want. My aim in writing it has been to deal with the pests observed in Meopotamia, but to give at the same time a summary of all that has been written up till the present time, and a full bibliography. From the bibliography I have excluded all purely popular references to well-known pests, all reports, etc., which merely record the presence of one of these pests in some place in which it is well known to occur, and papers relating solely to the systematics of the pests.

I am indebted to Prof. R. Newstead, Mr. E. E. Green, Mr. G. J. Arrow and Mr. J. H. Durrant for much help most kindly given, and to the staff of the Imperial Bureau of Entomology, who have always assisted me in every possible way.

LEPIDOPTERA.

Family **HESPERIIDAE.**

Padraona palmarum, Moore.

This butterfly is recorded by Stebbing from leaves of date palms at Calcutta.

Family **PYRALIDAE.**

Subfamily PHYCITINAE (= ANERASTIINAE).

Myelois phoenicis, Durrant.

This species was described by Durrant (1915) from a specimen bred by Lord Walsingham in 1904 at Hammam-es-Salahin, Constantin, Algeria. The larva was found in dates. The species has since been found in England and France in imported dates, and as Durrant remarks, "may be widely spread by commerce."

Plodia interpunctella, Hb.

According to Popenoe the Indian meal moth is a serious pest of stored dates in Arizona. This is the only record I have found of this omnivorous and very widely distributed species attacking dates.

Spermatophora hornigii, Léderer.

Moths which I bred at Basra in September 1917, and Baghdad in September 1918, from larvae found in August feeding in wind-fall dates, have been identified by Lord Rothschild as this species. He informs me that Léderer's original specimens also came from dates, but I have been unable to consult the original reference. The species appeared to be quite common in Mesopotamia, but was in no sense a pest.

Ephestia calidella, Guenée.

Gough (1917) mentions that in Egypt the larvae of this species sometimes attack living dates on the tree, and bore into them through the rind. These larvae spin silk at all times in their life-history, and lower themselves on a silken thread when they are alarmed. In these respects the habits of this insect differ from those of the *Ephestia* in the Khargeh oasis. This species occurs at Baghdad and Amara, but I have no evidence that it is a pest.

Ephestia cautella, Walk. (*Ephestia passulella,* Barrett.)

This species is a common warehouse pest in Basra, and probably throughout Mesopotamia. The larvae also enter windfall dates in the gardens in Baghdad, Amara, and Basra, passing into the fruit at the point at which it has become detached from the perianth. These windfall dates are frequently harvested by the less well-to-do, who in this way infect and reinfect their stores and godowns with *E. cautella.* It is a common thing to see masses of dates which have been riddled by this and other Pyralid moths exposed for sale in the bazaars; these spoilt dates are bought for feeding domestic animals.

The larva of *E. cautella* not only eats ripe dates which have fallen to the ground, but also the small " hashaf " dates which have become hard and withered owing to the attacks of the Gelechiid moth (see below) while they were half grown.

According to Smyth the life-history from egg to adult occupies five weeks in summer at Smyrna ; in April, May and June about 48 days. Chittenden says that this species has a wide distribution in Europe, Asia, North Africa and North and South America ; it was originally described from Ceylon.

It has been recorded as attacking pomegranates, pears, cotton cake, cacao beans, gall-nuts, flax-seed meal, tonka beans, walnuts, pecan nuts, pea-nuts, figs, pearl hominy, dried moths (specimens), stored corn, asparagus berries, white rice, chick pea, zizyphus berries, etc.

Chittenden and Smyth's Bulletin should be consulted for details of the life-history of this pest, and for an account of the damage it does to stored figs. Buckler described its life-history (under the name *Ephestia passulella*) in 1882.

It is parasitised in Egypt by *Habrobracon kitcheneri*, Dudgeon & Gough.

Ephestia sp. ?

Gough (1917) describes the life-history of an *Ephestia* which is not identified but differs from *E. cautella* and *E. calidella*. This larva is a pest of fallen and harvested dates in the Dakhlah and Khargeh oases, which lie in the desert west of the Nile. The life-history is given as follows. The female lays as many as 190 eggs in 24 hours, and this is not the full number ; the eggs are deposited in ones and twos on the surface of the dates after they have fallen or been gathered. The larvae wander about and are not able to enter living dates, a point in which they differ from the larva of *E. calidella*. They generally enter a stored date by the calyx end, and take up their abode in the space between the flesh and the stone. After feeding for a minimum of 20 days, during which no silk is spun, the larvae emerge from the date and wander about, leaving a silk thread behind them ; they wander for two days, leaving their thread on all the dates over which they pass, and then spin a cocoon in some convenient corner. The minimum life period from egg to adult is 25 days in August, 27 in September, and 38 in October, in Egypt. The species passes the winter in the larval stage. The adult moths are crepuscular and nocturnal, and never fly far.

Gough suggests that arrangements should be made for marketing the dates in two grades, and that the first grade should be treated with SO_2 after they are packed ; the second grade should be pressed, a process in which many of the larvae are crushed. He also speaks of the employment of moth-proof receptacles. I imagine that it will be some years before the inhabitants of these desert oases use either moth-proof receptacles or sulphur fumigation, but they can probably be induced to gather up their wind-falls and give them to their cattle to eat.

Subfamily Galleriinae.

Arenipses sabella, Hampson.

The larva of this species is known to eat stored dates, to which so far as we know it is confined ; in this respect it differs from *Ephestia* spp., which are pests of the

most catholic tastes, devouring almost all forms of stored produce. The larva is described by Durrant as dull pinkish-brown, head and plates darker, brownish spots darker, length 1 in. This species has been recorded from Fao, at the head of the Persian Gulf, in Arabia, also from Algeria and Persia (Hampson). As an imported species it has reached England, and has been reported from Canterbury by Hampson; in the British Museum there is a specimen bred from the larva described by Durrant; this larva was found by Miss B. Reed in dates in London. The species was common at Amara on the R. Tigris, males and females coming to light from April to June. It seems probable that Mesopotamia is one of the native countries of this insect. There is no record of it as a serious pest, but this may only be due to our ignorance of the moths whose larvae attack stored fruits.

Family **GELECHIIDAE.**

Genus and species unknown (text fig. 1).

This was by far the most serious pest of the date palms in Mesopotamia in 1918, and it was on account of its ravages that I was ordered to report on the failure of the date crop during that season. Unfortunately I received this order after the larvae had left the dates to pupate, and it is only owing to a fortunate chance that I was able to obtain a few larvae which had been preserved in whisky by one of the officers of the Department of Agriculture. These specimens enable me to say that the pest is a Tineid of the family GELECHIIDAE, if the tables given by Fracker for determining Lepidopterous larvae are correct. I have found his paper most useful, and I believe it to be accurate, but I think we must accept it with a certain amount of reservation, at any rate where the Microlepidoptera are concerned, because Fracker has been forced to base his conclusions on the examination of a comparatively small number of identified species of larvae. Text fig. 1 shows the chaetotaxy of this larva, and with the aid of it future investigators should be able to determine whether any pest with which they are dealing is identical with the one of which I am speaking. The explanation of the nomenclature of the setae will also be found in Fracker's paper. Apart from chaetotaxy the larva may be described as follows. The adfrontals reach the vertical triangle, and the frontals about half way up to the vertical triangle. The superior angle of the frontals is not prolonged into a fine point. The arrangement of the ocelli is that characteristic of the GELECHIIDAE and not the OECOPHORIDAE, a point which cannot be described without reference to a figure (cf. Fracker, Pl. viii, figs. 80, 81). The body is slightly flattened, and is widest at the third and fourth abdominal segments; the setae in general are short and inconspicuous, as is usual in internal feeders. The prothoracic shield is weakly chitinised and is not darker than the rest of the body; the legs are short. The abdominal prolegs are also short, and the crochets on them are uniordinal, and arranged in a complete series: the crochets of the anal prolegs (text fig. 1,D) are arranged in a continuous transverse row. The prothoracic spiracle is oval, the abdominal ones circular, that on the 8th segment the largest. I was informed that the larvae when alive were pink, without any markings.

This pest has apparently not been recorded before, and is so far as we know confined to Mesopotamia. Its biology is very little known, but its ravages were first detected by other observers in June. The half-ripe dates turned brown and

became spherical, and inside them the larva could always be found eating the flesh of the date along the stone; early in July the larva left the dates, which were by now quite dry and about half the size of a healthy date, making its egress by a hole bored close to the attachment of the perianth. From the hole one could always see frass and silk projecting. It is extremely rare to see two emergence holes from one date, and I believe that the eggs must be laid singly, probably on the fruit soon after it is set, and that the larva burrows into it and remains in a single date throughout its period of growth. All my efforts to find the place of pupation

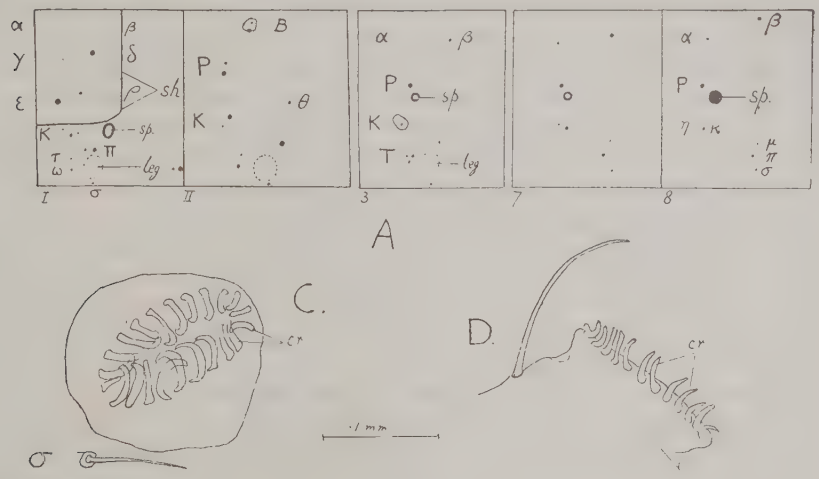


Fig. 1. Structural details of larva (Fam. Gelechiidae) causing damage to half-ripe dates in Mesopotamia. A. Chaetotaxy of pro and meso-thorax (I, II) and 3rd, 7th and 8th abdominal segments (3, 7, 8). The shield of the prothorax is drawn rather too wide and too deep. The head of the larva is supposed to be towards the left. C. Left proleg of 7th abdominal segment seen from below; the seta σ is in the direction of the mid-ventral line. D. Anal proleg seen from above.

Small Greek letters (α, β, τ, ω, etc.) indicate individual setae, according to Fracker's terminology. Greek capitals (B, K, etc.) indicate groups of setae, of regular occurrence in certain families or many families of the Lepidoptera, e.g., B = $\alpha+\beta$, P (capital rho) = $\epsilon+\rho$, T = $\tau+\omega+\phi$ (?), K = $\eta+\kappa$. *Cr.*, crochets of proleg; *leg*, proleg, or leg; *sp.*, spiracle; *sh*, dorsal shield of prothorax.

were unsuccessful. I searched cracks on the palm stem, the fibrous leaf-sheaths and the rubbish which accumulates in the crown of the tree; I also passed earth from beneath the trees through a sieve, without finding any pupae except those of large NOCTUIDAE. I believe that pupation takes place in the ground, and lasts throughout the winter, because we always observed that the incidence of the pest was slight in gardens in which a crop of winter and spring vegetables was cultivated beneath the trees. I opened a very large number of the dates which had fallen prematurely as a result of the attack of these larvae, and found no dead larvae, so it appears that the pest is not controlled by parasitic Hymenoptera or entomophthorous fungi.

This pest attacks all varieties of date palm, but it was particularly harmful to the Khustawi in Baghdad and Ba'qubah, and the Sair (Ista'mran) and Halawi in the Basra neighbourhood. The age of the tree appeared to make no difference to the severity of the attack, but it was an invariable rule that a heavy loss was sustained by owners of gardens far from the river, and by those who failed to keep the ground beneath the trees clear of weeds. Palms growing in rather salt ground, and those irrigated by the rise and fall of the actual sea at Fao were not particularly attacked by this insect. It will be understood that only a few sorts of palm will live under these conditions, but those that lived did not appear to be any less healthy than individuals of the same sort irrigated by fresh water. I have already said that the pest was never very serious in gardens in which green vegetables were cultivated beneath the trees ; I believe that this was due to the breaking up of the soil, and consequent damage to pupae, but we cannot regard this as proved until we know more of the biology of the insect. It was suggested that the very heavy incidence of this pest in the year 1918 was due to the fact that many of the cultivators had taken work in the Labour Corps, with the result that the gardens were less dug and ploughed than usual.

Until the life-history of this very serious pest is known, one cannot do better than impress on land-owners and cultivators the need to dig the ground beneath the trees in winter ; but if it is found that the female moth oviposits on the flowers of the female palm, or on the young fruit soon after it is formed, it might be worth while to protect the whole inflorescence with a muslin bag. Popenoe figures such bags in use to defend the ripening dates from wasps and birds.

It is impossible to estimate the loss due to this larva in 1918 ; I found evidence of its ravages in every garden I visited from Baghdad to Fao, and from Nasiriyeh on the Lower Euphrates to Khaniqin on the Kurdish border. Its predilection for the Sair dates of Basra is serious, as this is the most widely grown of all sorts and its fruit is exported to India in immense quantities. The more costly sorts suffer least, because no man owns more than a few trees, and these are always well-watered and carefully cultivated ; I refer to such sorts as Barhe, Braim, Maktum, and Mirhaji. I made a rough estimate that the following percentages of the crop of all varieties were lost, between the time when the fruit set and the harvest ; at Ba'qubah 50–70 per cent., at Qurnah 40–50 per cent., at Basra 30–40 per cent. The Basra date forest is the largest in the world, and contains about 7,000,000 palms. One may assume that the average yield of a palm is 60 lb. of fruit, and it will be realized that the loss of about a third of the crop is an extremely serious matter. This is the pest which I wrongly referred to in my report (1918) as a Pyralid. The attacked dates are called " hashaf " in Arabic.

COLEOPTERA.

Family **DYNASTIDAE.**

Oryctes elegans, Prell.

In Mesopotamia this species, for the identification of which I am indebted to Mr. G. J. Arrow, is common throughout the date-growing area : I have seen specimens from Baghdad, Ba'qubah, Balad Ruz, Mendali, Amara, Basra and Fao.

Adults fly to light from April to September and do great damage by boring through leaf-bases and stems of inflorescences in the crown of the tree. I have seen a garden littered with bunches of nearly ripe dates felled by this insect, which can be a most serious pest. I presume that the females lay their eggs in the burrows they make. Beetles of this species may also frequently be found in burrows in the hard trunks of living or dead palms, and I believe that these burrows are made either by the adult or the larva, but I have no proof that this is so. When these burrows are numerous they interfere seriously with the nutrition of the tree, and they sometimes cause it to break off in a high wind. The larva of a large Lamellicorn, which I believe is this species, lives in the crown of the date-palm among the leaf-sheaths, etc., and bores its way through the bases of leaves, the bases of fruit-bearing stems and the young leaves before they unfold. Sometimes it burrows inwards towards the actual growing point. It appears to have a predilection for fairly young trees, between the 10th and 20th year. It is an interesting fact that the larva of *O. rhinoceros* occasionally adopts the same habit, and lives in the crown of coconut trees, especially if they are decayed (Burkill); it is of course well-known that this larva normally inhabits piles of vegetable refuse, and old thatch and palm leaves which are lying on the ground. Such a habit would I think be impossible for the larva of *O. elegans*; for owing to the extreme desiccation of Mesopotamia it is generally impossible to find any decaying material of any sort in the gardens.

Treatment.—The presence of the adult or larva in the crown of a palm is known from the immense quantity of chewed vegetable fibre which passes through them and falls from the mouth of the burrow. When he sees this the Arab cultivator climbs the tree and endeavours to extract the insect with the short heavy knife with which he prunes his palms, and in so doing he frequently commits much havoc himself.

As Prell's *O. elegans* is very little known and was described from the female I have asked Mr. Arrow to re-describe the species. His description which is as follows is founded on a series of ten collected by W. E. Evans, C. F. C. Beeson and others.

"*Oryctes elegans*, Prell. This species has hitherto been known from its female only, examples of that sex taken at Fao having been described in a German periodical in July 1914 (Entom. Mitt. iii, p. 210.) It is one of the smallest representatives of the genus *Oryctes*, males ranging from 28 to 34 mm. in length, females from 34 to 36 mm. It is narrower in shape and rather less convex than *O. desertorum*, Arrow (found in the same region) and the upper surface is more smooth and shining, the elytra being almost devoid of the punctation occurring on the latter species, but possessing a deeply incised line on each side of the sutural edge instead of the row of dots found in *O. desertorum*. The two points of the clypeus diverge more widely and are separated by a rounded, instead of an angular excision. The armature of the head and prothorax scarcely differs from that of the other species, but the posterior edge of the thoracic cavity is rather more sharply toothed in the female, and rather less so in the male, which has only a very slight blunt projection there, not distinctly bicuspid as in *O. desertorum*. The cephalic horn

in the male is short, but in well-developed specimens longer than in the female. The thoracic cavity is similar in both sexes, except for the sharper posterior tooth in the female just mentioned. The pygidium is recurved in both sexes and has a fringe of red hairs on its free edge only; in the male it is convex and very smooth and shining; in the female it is more strongly inflexed and rather strongly and closely punctured. The last ventral segment in the male is also very smooth and its front and hind margins are straight and parallel; in the female it is strongly punctured, and forms a rounded lobe."

Oryctes desertorum, Arr.

Oryctes desertorum, G. J. Arrow, Fauna Brit. India, Coleoptera Lamellicornia (Cetoniinae and Dynastinae) 1910, p. 276.

The distribution of *O. desertorum* is given by Arrow as " India, Karachi; Persia; Arabia, Masqat (Muskat), Lahej and Fao." He tells me that the Persian specimen came from South Persia, so that all the records are from countries in which the date-palm is grown. It appears probable that *O. desertorum* will eventually prove to be a date-palm pest; at present however we know nothing of its habits or life-history.

Oryctes rhinoceros, L.

Burkill gives *Phoenix dactylifera* in a list of palms attacked by " the Rhinoceros Beetle." Stebbing records *O. rhinoceros* from date palms at Madras. On the other hand Copeland in his very careful account of the pests of the coconut does not mention the date palm in the list of trees which *O. rhinoceros* is known to attack, nor does Ghosh. *O. rhinoceros* is found from India eastwards, so that its range and that of the date palm only coincide in parts of India. It may well be that in that country it attacks this palm, as Stebbing has stated, but I do not feel that the matter is proved in view of the fact that the species of *Oryctes* have until recently been much confused. The life-history of *O. rhinoceros* is well-known, as it is a very serious pest of coconut. Ghosh's and Burkill's papers and Copeland's book should be consulted for details about this member of the genus and the measures which have been adopted to destroy it.

Family **Nitidulidae.**

Carpophilus dimidiatus, F.

Popenoe speaks of this species (as " *Carpophyllus dimidiatus* ") eating stored dates. The ordinary " Dried Fruit Beetle " is *Carpophilus hemipterus*, L. The parts of Popenoe's book which deal with pests of the date tree are not as valuable as the rest of the book.

Family **Anobiidae.**

Coccotrypes ? dactyliperda, F.

Willcocks records small beetles, which he believes to be this species, from Amry and Aglawy dates from the Sharkia province of Egypt. As many as 11·8 per cent. of the latter variety have been found infected. The beetles live in a cavity hollowed out of the date stone, in which as many as forty eggs, larvae, pupae and imagines may be found. A small circular hole communicates between the cavity and the exterior.

Family **Curculionidae.**

Rhynchophorus ferrugineus, Oliv.

Popenoe states that the "Coconut Palm Borer, *Rhynchophorus ferrugineus*, has killed date palms in India, and to less extent in Mesopotamia." Opposite p. 168 he gives a plate of two dying palms nearly leafless, under the title "Ravages of the Palm Borer." However in a footnote he says that "he did not see the borer itself in Baghdad," and his record appears to rest on descriptions received from Arab sources. As far as I am aware this very large and conspicuous weevil has never been obtained in Mesopotamia. Captain W. Edgar Evans, R.A.M.C., never saw it though he lived in Amara, an important date-growing centre, for about a year and made a very extensive collection of beetles; it is absent also from one or two smaller collections of beetles received from that country by the British Museum.

In India, on the other hand, this weevil is definitely known to attack the date palm, and MacKenna tells us that it is capable of inflicting considerable damage. It is found that the palm may be saved from attack if mud enclosures are built round the trunk and kept filled with water. Milne figures palms the tops of which have bent right down owing to this weevil. It is important to cover with earth or tar the raw surface from which an offset has been detached. This weevil is distributed from India to the Philippines (and possibly to New Guinea also). Burkill gives a list of half a dozen palms from which it has been recorded, the chief of them being the coconut, of which it is a major pest.

It will possibly be found that other species of *Rhynchophorus*, e.g., the African *R. phoenicis*, occasionally attack date palms.

Thysanoptera.

Family **Thripidae.**

Heliothrips haemorrhoidalis, Bch.

This insect is recorded by Williams as having been found on date palm in Trinidad. It is the species known as the "Greenhouse thrips," and has been recorded from every continent and has a long list of food-plants. It is not a pest of the date palm.

RHYNCHOTA.

Family **Coccidae.**

Parlatoria blanchardi, Targ.

Aonidia blanchardi, Targioni Tozzetti, Mem. Soc. Zool. France, v, pp. 69–82, 1892 (from Ourir, Shott Melrir, Algerian Sahara).

Parlatoria victrix, Cockerell, Arizona Exp. Stn. Bull. 14, 1895; and Entomologist xxix, p. 52, 1896 (on imported date palms).

? *Parlatoria proteus* var. *palmae*, Maskell, Trans. and Proc. New Zeal. Inst. (1897) xxx, p. 229, 1898 (on date palms imported from Algeria into Australia).

Parlatoria (*Websteriella*) *blanchardi*, (Targ.), H. H. King, Rept. Wellcome Res. Labs. Khartoum, iii, p. 240, 1908.

Cockerell himself states that his description of *Parlatoria victrix* was made from dark specimens of the species previously named *Aonidia blanchardi* by Targioni Tozzetti.

Distribution.—This pest has been recorded from the following localities :

Algeria : Ourir, S. of Shott Melrir. Egypt : Assouan, Cairo, Luxor. Sudan : Khartoum and N. Sudan generally. Italian Somaliland : Merka. Mesopotamia : Probably throughout the date area ; certainly Basra and Amara. India : Lyallpur, Punjab. United States : Arizona, California. Australia : Northern Territory.

I can find no record of the occurrence of this scale-insect in Morocco, Tunisia, Tripoli, Arabia, or S. Persia.

P. blanchardi was introduced into the Southern States of the U.S.A. in 1890 from Cairo and Algiers (Cockerell), or in 1889 (Popenoe). It was introduced into Australia about 1894 (Maskell), but has apparently not yet reached South Africa. (Lounsbury).

Biology.—In Mesopotamia this scale occurs on the upper side of the leaflets, more rarely on the midrib ; it attacks particularly recently planted off-sets and the resultant young trees during the first half dozen years of their life. I saw it on various types of date palms at and near Basra, and on the variety known as " Zehedi " at Amara. I did not notice it in the other parts of Mesopotamia to which I travelled in the course of the investigation. I never saw a tree severely attacked, even in the most neglected gardens far from the river. I believe that the comparative scarcity of this insect is due to the attacks of *Aphelinus mytilaspidis* (Eulophidae).

Males were easily obtained in October by enclosing leaflets attacked by the scale in a bottle.

This scale on the date leaf is known to the Mesopotamian peasant as " rēmāj " ; I have not been able to find this word in any dictionary.

The most complete account of this scale is the pamphlet by Cockerell and Forbes (1907), to which I am indebted for a great deal of information. It is clear from all the American authors that it is a very serious pest, not only because it weakens the palm by almost covering the leaves, which turn yellow when heavily attacked, but also because it invades the fruit and renders the dates unsightly and hardly fit for the market. We know that it is also a very serious pest in the old world ; King speaks of dates exposed for sale in the Sudan " smothered with " *P. blanchardi*, and Targioni Tozzetti's original description of the species mentions date leaves from the Sahara covered on both surfaces by overlapping scales of this species. Essig says it may kill the tree in California. Cockerell (1907) states that it is attended by the ant, *Pheidole cockerelli*, Wheeler, at Tempe, Arizona.

He and Forbes (1907) make the interesting suggestion that the young insects may be carried from tree to tree by wind, birds, or rats, or by fruit-pickers and pruners. Young offsets are frequently infested by both this and *Phoenicococcus* at the time when they are pushing their way through the old matted leaf-bases left on the trunk of the parent tree.

Other Hosts.—Fide Cockerell (1907), *Parlatoria blanchardi* has been recorded by Newstead (1906) from jasmine foliage. King (1908) says Draper (1907) has recorded it from yellow jasmine and periwinkle. It does not appear to have been recorded from any other plant.

Parasites and other Enemies.—Cockerell (1907) records *Coccinella abdominalis* and *Chilocorus cacti* (COCCINELLIDAE) as feeding on this scale in America ; to this (Mthly. Bull. Sacramento, 1913, p. 139) we can add *Scymnus* sp. Popenoe states that there is a parasite which perforates this scale in Algeria, but it has not yet been investigated. No doubt this is some small Hymenopteron. Cockerell (1907) has once seen the emergence-hole of a Hymenopteron in a scale of *P. blanchardi* in America.

In October 1918, at Amara, R. Tigris, in Mesopotamia, I bred a small Eulophid wasp from *P. blanchardi*. This parasite has been determined by Mr. J. Waterston as *Aphelinus mytilaspidis*, Baron. It was extremely common, and it appeared probable that it was an important agent in controlling the scale, which so far as I know is never a serious pest in Mesopotamia. It would probably not prove worth while to import this Eulophid into other countries in which the date is a main crop, because we know that the parasite is already widely distributed. According to Mercet, *Aphelinus mytilaspidis* has been found in U.S.A., Ceylon, Italy, France, and Spain, and is known to parasitize the following scales :—in America, *Lepidosaphes ulmi* (*Mytilaspis pomorum*), *Chionaspis pinifolii*, and *Diaspis carueli* ; in Ceylon, *Chionaspis permutans* and *C. graminis* ; in Italy, *Aspidiotus hederae* and *A. betulae* ; in Spain, *A. hederae* and *Diaspis rosae*. It has not apparently been previously recorded from *Parlatoria blanchardi*.

Treatment.—Forbes (1907) states that treatment designed to exterminate *Parlatoria blanchardi* and *Phoenicococcus marlatti* has to be extremely thorough, because the scale-insects persist, even in small numbers, among the closely crowded bases of the great leaves. The reader must realize that the whole crown of the tree is enveloped in sheets of fibrous matting which arise between the petioles of the leaves where they are inserted on the trunk. Any scale-insects which happen to be in this tightly-bound tangle escape soap and kerosene emulsion, whale-oil soap, distillate spray, resin wash and even fumigation with hydrocyanic acid vapour. There remain two treatments which are said to be efficacious. Wilsie (1913) tells us that after the great fire in San Francisco " the ornamental palms withstood the great heat, and put out new leaves at once after the fire." This observation suggested the treatment described by Forbes (1913) ; the trees are pruned down to the crown and all the great leaf bases, and the fibre in which they are set, are removed as much as possible. When the tree has been reduced to a bare pole it is drenched with paraffin and fired, after which the surface is flamed with a gasolene blast, several times in the first few months, in order to destroy such few pests as may be finding refuge in cracks and similar places. This treatment does not kill the tree but destroys the *Parlatoria* and *Phoenicococcus*. Popenoe (1913) says that the gasolene torch treatment puts the young palm back two years and is unpopular with the growers for that reason. He states that all offsets are now dipped bodily in a tank of cresol dip, and adds that " this destroys the scale so that no danger need be feared from

it." A plate is given showing the process in operation. I have no experience of this method but do not understand how any dip can penetrate the spaces between the leaf bases. No one but those who have endeavoured to separate date leaves from the trunk or even from a small offset can realize how firmly the petiole is attached to the plant, and what an ideal refuge there is among all the fibrous material which surrounds the bases of the petioles.

Parlatoria zizyphi, Lucas.

Various early authors refer to this scale as a pest of the date palm, and an unsigned editorial article in Insect Life (1891) definitely says that " specimens proved on comparison to be identical with *P. zizyphi* Lucas." There appear to be no more recent records of *P. zizyphi* from date palms, and the above record dates from before the publication of the description of *P. blanchardi*, to which it possibly refers.

Phoenicococcus marlatti, Ckll.

Phoenicococcus marlatti, T.D.A. Cockerell, Proc. Acad. Nat. Sci. Philadelphia (1899), 1900, p. 262 (from imported Algerian date palms).

Sphaerococcus draperi, R. Newstead, Quart. Jl. Inst. Comm. Res. in Tropics, 1906 (from Egypt).

Prof. Newstead tells me in a letter that his *S. draperi* is certainly identical with Cockerell's *P. marlatti.*

Distribution.—Egypt and Algeria, both the Tel or Mediterranean coastal plain and also the Saharan Oases. As an imported species, California and Arizona.

Biology.—I failed to find this species in Mesopotamia. Very little seems to be known of its habits. Cockerell (1899) says that the female is 1–1¼ mm. long, and wine-red in colour ; she secretes wax but makes no true scale ; the embryos grow to a large size in the body of the female. Marlatt found it, according to the same author, occurring packed in great numbers " in little cavities about 10 or 12 mm. long by 4 or 5 broad on the midribs of the leaves, communicating with the air by a narrow longitudinal slit," on date palms imported into America from Algeria. The slight swellings containing the insects are very inconspicuous, and very likely to be overlooked even on a close examination. Later Cockerell himself found it on the sides of the sheathing bases of the leaves ; in this case it was not beneath the epidermis, and Forbes (1907) speaks of it as remaining close to the trunk among the great overlapping leaf-bases. Wilsie speaks of it as completely covering the stalk of the inflorescence near its base, where it is completely concealed by the leaf-bases. Probably Marlatt's original description of the *Phoenicococcus* living in cavities on the leaf-base was taken from specimens which had started growing on very young leaves ; as the leaf grew the tissues might have swollen round the colony of the scale-insect in such a manner as very nearly to cover it. Trabut's most interesting note describes a date palm disease known to the natives of the oases of Zibans in the Sahara as " khamedj" : this is caused by a heavy infestation of the stem of the inflorescence by *P. marlatti.* The disease becomes evident in the late spring soon a ter fertil sation ; the whole inflorescence dries up and no fruit develops. This calamity happens to 5 per cent. of the trees, nearly the whole of

which are to some extent attacked. The Arabs treat the condition by free excision of leaves down to the bole, and occasionally by removal of the terminal bud itself. Forbes (1913) records that this pest occasionally attacks exposed roots of date palms.

The male of *Phoenicococcus marlatti* is unknown.

No parasites or natural enemies of this scale have been recorded.

Icerya aegyptiaca, Douglas.

This scale-insect is recorded by Newstead (1917) from a young date palm at Zanzibar. So far as I am aware this is an isolated record. This species has a long list of host plants, and in Ceylon at any rate attacks various kinds of palms, some of which are badly infested.

Selenaspidus (Aspidiotus) articulatus, Morg.

The West Indian red scale has been recorded by Morstatt from "Phoenix palm," from German East Africa. I am not perfectly certain whether this refers to the date palm, or to some wild member of the genus. In any case it is an isolated record of a Coccid which has been found on a variety of plants, including olive, rubber, citrus, coffee, bananas and cacao.

Aspidiotus ostreaformis. Curtis.
Aspidiotus hederae, Vallot.
Chrysomphalus aonidum, L.
Chrysomphalus aurantii, Maskell.
Coccus hesperidum, L.

These five scales are all general feeders; they are all recorded by Essig as occasional minor pests of the date palm in California.

Mr. E. E. Green has been good enough to furnish me with the following list of Coccidae which have been recorded from the genus *Phoenix*:—

Icerya aegyptiaca, and *purchasi*.

Phoenicococcus marlatti.

Pseudococcus nipae.

Lecanium hesperidum, tessellatum, oleae, and *expansum*.

Diaspis phoenicis, and *boisduvalii*.

Chionaspis dilatata.

Aspidiotus ostreaeformis, dictyospermi, ficus, rapax, lataniae, hederae, cyanophylli, and *articulatus*.

Parlatoria blanchardi, proteus var. *palmae, zizyphi*, and *pergandei*.

Fiorinia pellucida.

Ischnaspis filiformis.

Acarina.

Family **Tetranychidae.**

Oligonychus (Paratetranychus) ? simplex, Banks.

Mr. Hirst has examined some of my specimens of a small "red spider" from date palms and believes that they are the *Paratetranychus simplex* described by

Banks (Journ. Ent. Zool. Claremont, vi, 1914); it is apparently impossible to feel certain on this point. Mr. Hirst (1920) has re-described the species and figured the penis and the palp of the female.

This mite is a most serious pest of growing dates in all parts of Mesopotamia which I visited. It was first noticed in early July, when immense numbers were found spinning webs all over the clusters of growing dates. These webs are of considerable extent and stretch from date to date over the whole cluster; dust becomes entangled in the web and the dates beneath never ripen properly. At the time when healthy dates are ripe the affected ones are discoloured and scaly, and as they are scarcely fit to eat and quite unsaleable they are generally used as food for cattle and horses. These diseased clusters are for some reason attractive to the wasp *Polistes hebraeus*, which may constantly be seen hovering over them and crawling on the surface of the webs. I was quite unable to find why the wasp acted in this manner, but I should imagine that its doing so must be a factor in the spread of the mites from tree to tree; the wasp does not frequent the clusters of ripening dates unless they are attacked by the mite. The disease is found on many varieties of dates, especially the Khadhrawi, Dairi and Zehedi; in 1918 it was a most serious pest of the first of these, which is a widely grown date of superior quality and was not attacked by the Gelechiid moth. I have seen clusters of dates on trees of all ages attacked by this mite, but it was always to be observed that its ravages did not cause serious damage except to trees far from water or growing in ill-kept unweeded gardens. It is not confined solely to such trees; indeed I have seen it on a Khadhrawi which was growing on the very margin of a tidal creek at Basra. The disease is known to the Arabs as Toz, Trab, and Ajaj, all of which words mean solely dust; it is stated to come from Allah, but more immediately from the dust of the roads.

Other Insect Pests.

Mr. H. H. King informs me that in some years the migratory locust (*Schistocerca peregrina*, Oliv.) eats all the leaves and fruit on date palms in the Sudan, and Popenoe mentions that locusts are occasionally troublesome in California and Arizona, and in Algeria. He gives no further information, but we may presume that the adults of some species devour the dates on the tree. He makes some even more indefinite remarks about ants and termites, and also mentions bees and wasps. I have alluded above to the fact that *Polistes hebraeus* frequents clusters of dates infested by the mite *Oligonychus simplex*, Banks. The Oriental hornet (*Vespa orientalis*) never, I believe, attacks fruit on the trees except that which has been already pecked by birds, but it devours the fruit exposed for sale in the bazaars, and is so large and abundant that it must cause appreciable loss in all parts of Mesopotamia in which dates are grown.

Animal and Bird Pests.

Popenoe tells us that a horde of rats at Tempe, Arizona, once did great damage to the date crop, and mentions that gophers and jack rabbits eat the offsets; he states that at Baghdad a "squirrel-like animal" eats the fruit. The Mammalia of Mesopotamia are now well-known, but I am not able to guess which animal he was referring to; probably it is the mongoose (*Mungos persicus*), which is common

in the date gardens and is known in Arabic as "palm-tree rat"; the mongoose is no doubt largely a vegetable feeder, but I do not think that it is in any way a serious pest of the date.

In Mesopotamia birds undoubtedly eat a very large number of dates just before they are picked: *Hypocolius ampelinus* has been observed in Baghdad gorging itself and damaging many more dates than it could devour, and the bulbul (*Pycnonotus leucotis mesopotamia*) and house-sparrow (*Passer domesticus*) are also destructive. Mr. H. H. King informs me that the Spanish Sparrow (*Passer hispaniolensis*) pecks young dates in the Sudan. Milne adds parrots and monkeys to the list.

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* Articles marked with an asterisk have not been examined by myself personally.

Postscript.

As this paper goes to press I have had an opportunity of examining the MS. of a "Note on Dates and Date Palms in Iraq" by Mr. V. H. W. Dowson, which will shortly be published by the Directorate of Agriculture, Mesopotamia. I have also seen the "Administration Report of Agricultural Directorate for the Year 1919" (Baghdad Govt. Press, 1920), which contains the report of C. R. Wimshurst, Entomologist. From these sources I gather that a "minute larva has been found in the inflorescence of a date palm immediately after its exit from the spathe"; this is presumably the newly hatched larva of the unknown Gelechiid. Spraying with cold water at intervals of a few days is reported to be a valuable means of controlling the red spider (*Oligonychus*). *Silvanus surinamensis*, L., and *Laemophloeus* sp. (Coleoptera, Cucujidae) are added to our list of pests of stored dates.

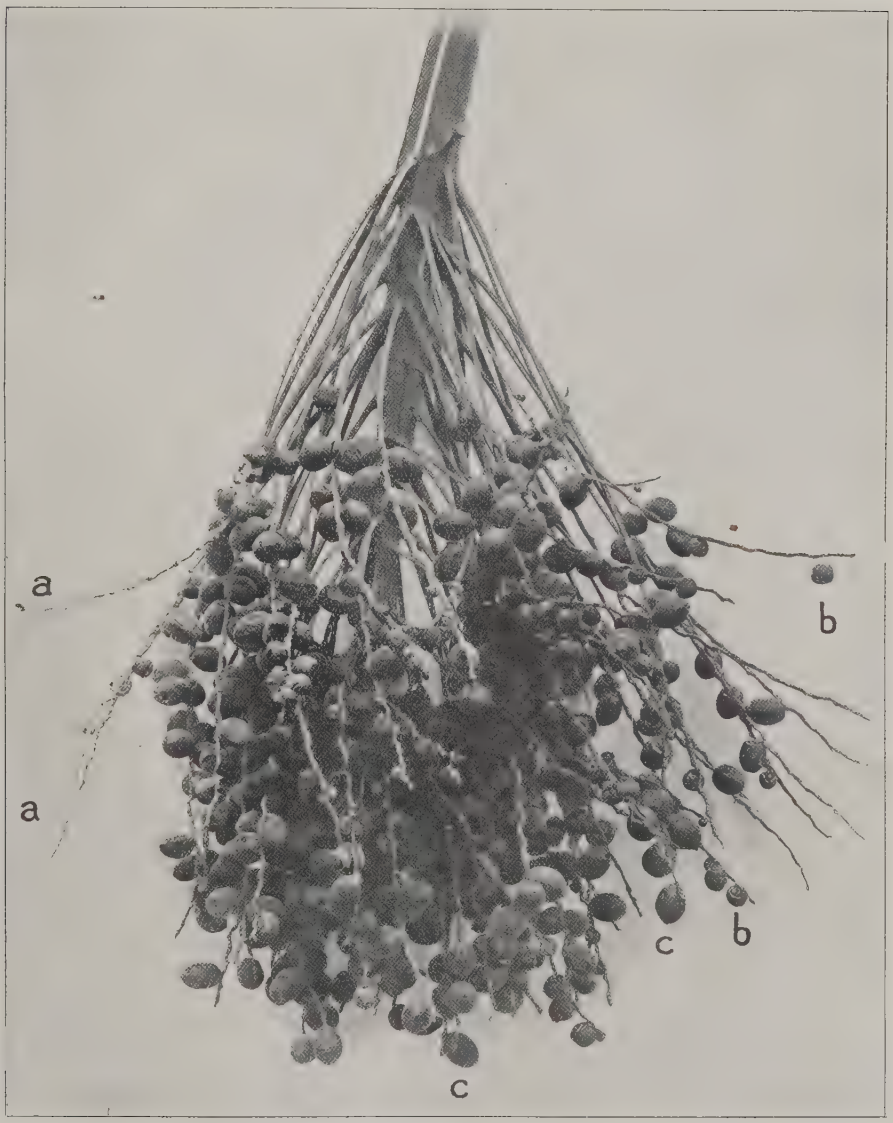
EXPLANATION OF PLATE VIII.

A bunch of dates photographed in early August when growth of the fruit had practically ceased and ripening was just commencing :

a, pedicel from which all the dates have fallen owing to the attacks of the larva of a moth (Fam. Gelechiidae) ; as will be seen, the perianth falls as well as the unripe date.

b, dates destroyed by the larva, but which have not yet fallen ; notice their small size and spherical shape ; they are quite hard and dry ; such dates are known in Arabic as " hashaf."

c, healthy dates.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ON THE GENUS PHLEBOTOMUS.—PART IV.

By R. Newstead, F.R.S.,

The School of Tropical Medicine, Liverpool.

The following notes may be regarded chiefly as materials towards the study of the geographical distribution of this group of the bloodsucking midges, which are of so much interest from a medical standpoint. For the opportunity of examining the very large series of specimens (570) herein recorded, I have to thank Dr. Guy A. K. Marshall, Director of the Imperial Bureau of Entomology, who sent the collections made by Drs. A. Ingram and J. W. Scott Macfie, in the Gold Coast; and also that formed by Capt. J. Waterston, R.A.M.C., in Macedonia. I tender my thanks also to Capt. P. A. Buxton, R.A.M.C., for the collections made by him at Amara, Mesopotamia; to Capt. H. W. Leatham, R.A.M.C., for examples from Basra; and to Major J. A. Sinton, V.C., I.M.S., for the specimens which he collected in N.E. Persia, under exceptionally difficult circumstances, and also for the long series taken by him in the N.W. Frontier Province of India.

I may add to this short communication that the determinations of the specimens herein recorded are based upon material which was carefully prepared and stained for microscopical examination, as by this means the minute taxonomic characters can be seen and studied with greater accuracy and ease.

Phlebotomus antennatus, Newstead.

Male (hitherto unknown). *Pale form.* Drab or straw-coloured; fringe of costa, anteriorly, rather strongly infuscated, that of the posterior margin not so. Hairs

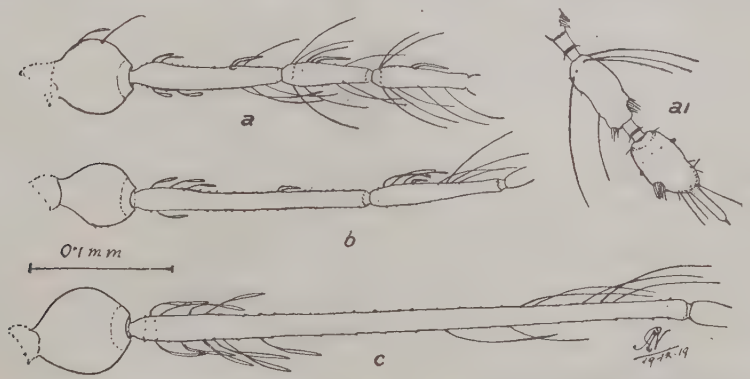

Fig. 1. *Phlebotomus antennatus,* Newst., ♂; *a,* proximal segments of the antenna; a_1, terminal segments. *P. minutus africanus,* Newst., ♂: *b,* proximal segments of antenna. *P. similimus,* Newst., ♂: *c,* proximal segments of antenna. The figures *a, b,* and *c* are drawn to the same scale; a_1, at a much higher magnification.

on wings and scales on legs very faintly iridescent in a strong light. *Dark form.* Wing very heavily infuscated, especially the costal fringe on both margins; the hairs beautifully iridescent, and in certain lights strongly resembling the rich deep blue of lapis-lazuli. The scales of the legs are also iridescent in certain lights,

the predominant blue colour being almost as intense as that of the wings. Hairs on the proximal segment of the abdomen erect; those on the remaining segments recumbent. Antennae with the segments (fig. 1, *a*) only very slightly longer than those of the female; the geniculated spines unilateral* and unpaired. Wing rather narrowly lanceolate. External armature precisely similar to that of *P. minutus*, Rond.

Length, 2–2·4 mm.; wing 1·2 mm.; leg iii, 2 mm.

Gold Coast: Accra, in laboratory. vi. 19, 38 ♂♂, 59 ♀♀ (*Dr. J. W. Scott Macfie*); Kwaman, 10.viii.18, 1 ♀; Navarro, on walls of M.O's. quarters, 22.vi.18, 1 ♀; Yamalaga, 18.v.18, 1 ♀; Salaga, on walls of M.O's. quarters, 10.v.18, 1 ♀; Yeji, 6.v.18, 1 ♀ (*Dr. A. Ingram*).

Phlebotomus ingrami, Newstead.

Gold Coast: Chechewere, 9.viii.18, 1 ♂ (*Dr. A. Ingram*).

Phlebotomus minutus, Rondani.

Macedonia: near Salonica, 1918, 1♂, 1♀ (*Capt. J. Waterston*). Mesopotamia: Amara, River Tigris, 1.ix.18, 1 ♂, 20 ♀♀ (at light); 8.ix.18, 2 ♂♂, 5 ♀♀ (at light); 19.ix.18, 1 ♀; 30.ix.18, 1 ♂, 9 ♀♀ (at light); 1.x.18, 2 ♀♀; 14.x.18, 1 ♂ (at light) (*Capt. P. A. Buxton*). India: N.W. Frontier Province, Dera Ismail Khan, viii. 1919, 33 ♂♂, 34 ♀♀ (*Major J. A. Sinton*, V.C.).

Phlebotomus minutus africanus, Newst.

Gold Coast: Yeji, 6.v.18, 1 ♀; Malowe, 29.vii.18, 1 ♂, 2♀♀; Accra, 4.i.19, 2 ♂♂, 1 ♀; Lilixia, 4.vii.18, 3 ♂♂, 3 ♀♀; Diari, on Rest House wall, 26.v.18, 1 ♀; Gambaga, in latrine, 1.vi.18, 7 ♂♂, 1 ♀; 5.vi.18, 1 ♀ inside mosquito net; Salaga, on walls of M.O's. quarters, 10.v.18, 6 ♂♂, 3 ♀♀; Jugbe, 1.viii. 18, 1 ♀; Sekodumase, 8.viii.18, 2 ♂♂, 11 ♀♀; Tili, on walls of Rest House, 14.vi.18, 2 ♂♂, 1 ♀; Nangudi, on walls of Rest House, 15.vi.18, 3 ♂♂, 7 ♀♀; Kulmasa, 22.vii.18, 1 ♀; Nandawli, 15.vii.18, 2 ♂♂, 4♀♀; Bole, 26.vii.18, 1 ♂; Chechewere, 9.viii.18, 1 ♂, 3 ♀♀; Bawku, 12.vi.18, inside mosquito net, 3 ♀♀; Savelugu, Rest House, 25.v.18, 2 ♂♂, 2 ♀♀; Wa, Rest House, 20.vii.18, 1 ♀; Navarro, on walls of M.O's. quarters, 22.vi.18, 2 ♂♂, 4 ♀♀; Bawku, on walls of quarters formerly belonging to M.O., 10.vi.18, 5 ♂♂, 1 ♀; Banda Nkwanta, 30.vii.18, 2 ♂♂, 6 ♀♀; Maibindiga, on walls of Rest House, 31.v.18, 2 ♀♀; Palbe, 16.v.18, 1 ♀; Kwaman, 10.viii.18, 1 ♀; Zovaragu, on walls of D.C's. quarters, 16.vii.18, 1 ♂, 2 ♀♀; Tishi, on walls of Rest House, 1.vi.18, 1 ♂, 1 ♀; Kpalgu, on walls of Rest House, 30.v.18, 1 ♀; Yamalaga, 18.v.18, 1 ♀ (*Dr. A. Ingram*); Accra, in laboratory, vi.19, 3 ♂♂, 4 ♀♀ (*Dr. J. W. Scott Macfie*).

Phlebotomus papatasii (Scopoli).

Mesopotamia: 30.vi.18, 1 ♂, 3 ♀♀; Amara, River Tigris, 14.vi.18, 1 ♀; viii.18, 1 ♂, 5 ♀♀; 2.ix.18, 3 ♀♀ (biting man); 21.ix.18, 1 ♂ (*Capt. P. A. Buxton*). Macedonia: near Salonica, 1918, 14 ♂♂, 35 ♀♀ (*Capt. J. Waterston*). India: N.W. Frontier Province, Dera Ismail Khan, viii. 1919, 3 ♂♂, 3 ♀♀ (*Major J. A. Sinton*, V.C.). Asia Minor: Trebizond, 5 ♂♂, 3 ♀♀ (*Dr. B. Uvarov*).

* This rather remarkable character is common also to the males of the following species: *P. minutus*, Rond., *P. minutus africanus*, Newst., and *P. simillimus*, Newst. (see fig. 1 *b*, *c*).

Phlebotomus perniciosus, Newstead.

Macedonia: near Salonica, 1918, 26 ♂♂, 9 ♀♀ (*Capt. J. Waterston*). Caucasia: Borzham, Province of Tiflis, 16.viii.1919, 8 ♂♂, 3 ♀♀ (*Dr. Kandelaki*, per *Dr. B. Uvarov*).

Phlebotomus sergenti, Parrot.

Phlebotomus sergenti, Parrot, Bull. Soc. Path. Exot. x, pp. 564–567, figs. 1–11 (1917).

Phlebotomus caucasicus, Marzinovsky, Medical Review, Moscow, lxxxvii, nos. 13–14–15–16, pp. 612–614 (1917).

A large species somewhat resembling *P. papatasii* (Scop.) in colour and in the general arrangement of the body hairs. But the male of *P. sergenti* is abundantly distinct and may be recognised from all other species by the unique character of the genitalia, in which the great length of the sub-proximal spine on the superior claspers should serve at once to distinguish it from all the species possessing paired brushes (*peniculi*) of non-deciduous hairs between the superior claspers proximally. On the other hand, it is extremely difficult to give taxonomic characters for the separation of the female from that of *P. papatasii*. In a typical example of *P. sergenti*, generously presented to me by M. Parrot, I fail to find any structural difference by which it could be separated from the ♀ of *P. papatasii*, though it is decidedly smaller; and this applies also to the female of the variety herein described from Mesopotamia. In the females from Persia, however, the geniculated spines of the antennae are slightly longer than those on the corresponding segments in the African examples before me; and in one example the spines are also accompanied by a somewhat lunular-shaped, subcutaneous structure (? gland), which no staining has hitherto revealed in any of my preparations. On the other hand, the males from the two widely separated regions agree in all their morphological details and are clearly conspecific. There is, I think, no doubt also that the African and Caucasian species are one and the same.

Marzinovsky (*l.c.*) notes the close affinity of his *P. caucasicus* with *P. sergenti*, Parrot, but claims that it is distinguished from the latter in some details. These "details" are, however, not traceable either in his diagnosis or in his figure of the male genital armature. Thanks to Col. C. M. Wenyon I have been able to study a direct photographic print of the male genital armature taken from the original negative which was used by Marzinovsky in illustration of his paper, and this confirms my views as to the specific identity of the Caucasian with the African form.

The following description is based upon material collected in N.E. Persia by Major J. A. Sinton, V.C.:—

Male.—Palpi of five segments; 2nd and 4th about equal in length; the 3rd a little longer than the 2nd, laterally incrassate, the incrassation seen only in dorso-ventral view; sensorium well marked by the relatively large clubbed hairs; 5th a little more than twice the length of the 4th. Antennae with the distal end of the 3rd segment almost reaching to the tip of the proboscis; the tips of the paired geniculated spines on segments 3–15, inclusive, reaching a point very slightly in advance of the centre of all the segments with the exception of the 3rd. Wing

(fig. 2, *a*) somewhat lanceolate, the tip rather acutely pointed. Genital armature (fig. 2, *b*) with a pair of relatively large brushes or peniculi between the superior claspers proximally. Proximal segment of superior claspers very robust; distal segment about half the length of the first, strongly bifurcated distally, the tip of each

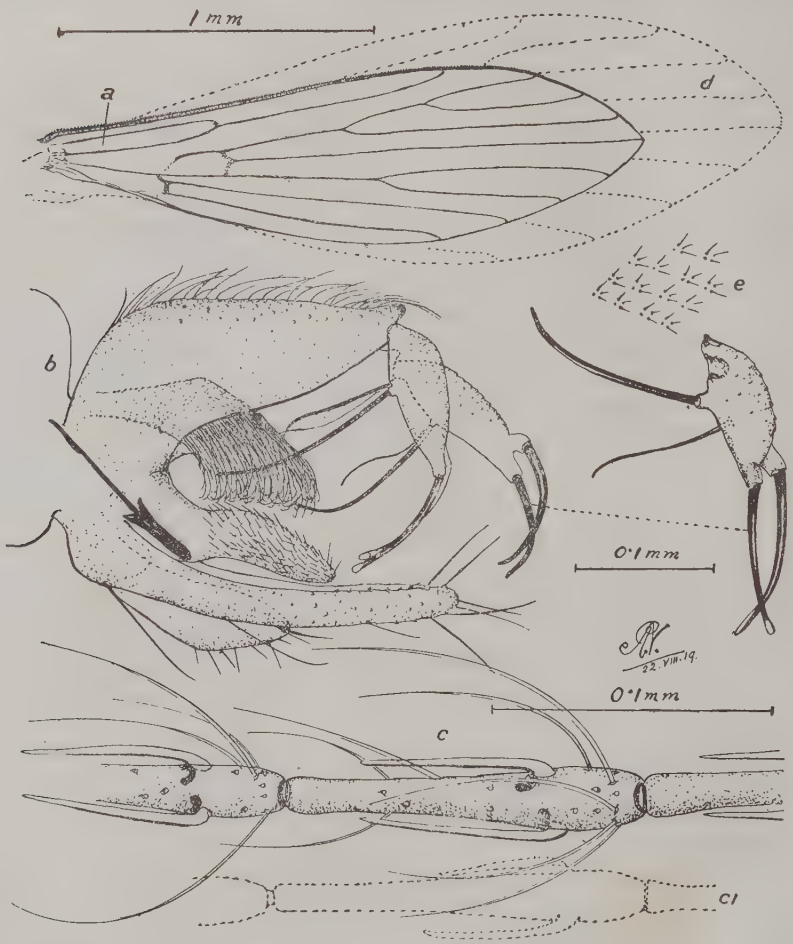

Fig. 2. *Phlebotomus sergenti*, Parrot: *a*, wing of ♂; *b*, genital armature of ♂; *c*, sixth segment of antenna of ♀, showing relative length of the geniculated spines and subcutaneous structures (? glands) near the bases of the former; c_1, dotted outline of the corresponding segment in *P. papatasii*; *d*, wing of *P. sergenti* ♀, in dotted outline, drawn to same scale as that of the ♂ (*a*); *e*, connective cuticle between tergites and sternites.

branch with an unusually long stout spine; near the proximal third of the segment is another pair of spines: the outer lateral one stout and of great length, the tip of which reaches almost to the base of the proximal segment of the superior clasper when the latter is closed (see fig. 2, *b*); the inner lateral spine much more slender,

generally curved distally and a little more than half the length of the longer outer one. The long inferior clasper extending beyond the distal end of the proximal segment of the superior clasper by one-fifth of its total length.

Length, 3 mm ; length of wing, 1·9 mm.

Female.—General facies similar to that of the male, but larger and generally more robust. Palpi precisely similar to those of the male. Antennae with the tip of the 4th segment extending very slightly beyond the proboscis ; the 3rd segment relatively shorter than the corresponding segment in the male ; the paired geniculated spines (fig. 2, *c*) extending considerably beyond the middle in most of the segments, while those on the 14th and 15th, respectively, extend to the articulation of the succeeding segment ; on many of the segments the spines are accompanied by a relatively large and somewhat lunular-shaped subcutaneous structure (? gland). Wing (fig. 2, *d*) much broader than that of the male, with the hind margin also much more strongly arched. Connective cuticle between the tergites and sternites (fig. 2, *e*) with a very regular diagonal pattern formed by equidistant groups of minute hairs, each group composed of four hairs.

Length, 3·7 mm. ; length of wing, 2·4 mm. ; length of leg ii, 3·9 mm. ; length of 3rd segment of antennae, 0·3 mm.

North East Persia : Meshed, vi. 1918, 5 ♂♂, 3 ♀♀ (*Major J. A. Sinton, V.C.*).

Phlebotomus sergenti, var.

Male.—Differing from typical *P. sergenti*, Parrot (*l.c.*) in having the 3rd segment of the antennae (fig. 3, *a*) relatively very much shorter and with the distal, bifurcating, spine-bearing process of the superior claspers (fig., 3 *b*) markedly unequal in length, the terminal process being about three times the length of the other.

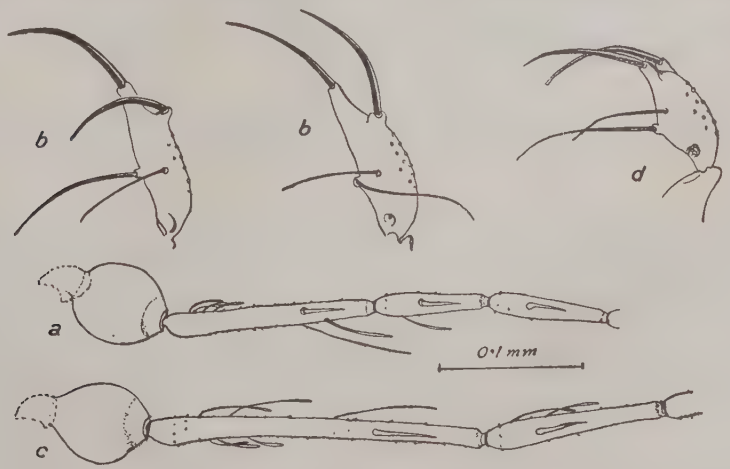

Fig. 3. *Phlebotomus sergenti*, var. ♂ : *a*, proximal segment of the antennae ; *b*, *b*, distal segments of the superior claspers.
Phlebotomus sergenti, Parrot, ♂ : *c*, proximal segments of the antenna ; *d*, distal segment of the superior clasper.
All the figures are drawn to the same scale.

The 3rd antennal segment (fig. 3, *c*) and the distal segment of the superior clasper (fig. 3, *d*) of *P. sergenti* drawn to the same scale as the corresponding structures in this var. are given for comparison and convenience of reference.

Mesopotamia: Amara, 1 ♂, taken at light, 19.ix.18 (*Capt. P. A. Buxton*); another ♂ from the same locality, but taken 1.ix.18, has been placed in the National Collection. There are also 6 ♀♀ which I attribute to this variety of *P. sergenti*, though I am not absolutely certain that they belong here; they bear the following data: Amara, River Tigris, 4.vi.18, 1 ♀; Mesopotamia, 30.vi.18, 3 ♀♀; Baqubah, River Diayala, 28.vii.18, 1 ♀; Amara, River Tigris, 18.x.18, 1 ♀ (biting man) (*Capt. P. A. Buxton*).

Phlebotomus signatipennis, sp. nov.

A small short-legged exceptionally hairy species; easily determined by the strikingly characteristic wing venation, in which the 1st sub-marginal cell is relatively very small indeed, the anterior branch of the vein being about one-fifth the length of the vein between the two forks.

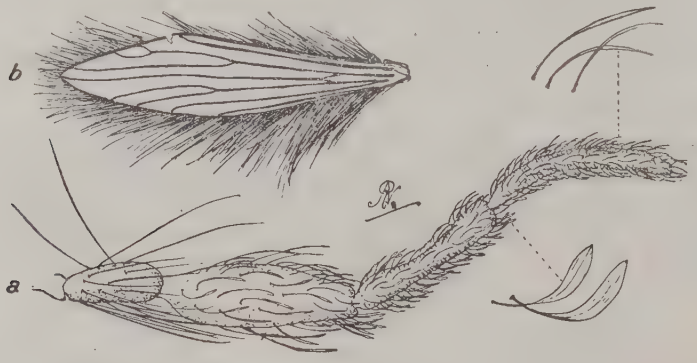

Fig. 4. *Phlebotomus signatipennis*, Newstead, ♀: *a*, palpus; *b*, wing; the latter drawn to the same scale as the wing of *P. sergenti* in fig. 2, *a*.

Female. Relatively robust, short-legged, and exceptionally hairy, the hairs heavily infuscated, more especially those which form the wing-fringe. Hairs on proximal portion of abdomen more or less erect, the longest reaching to the middle of the 4th segment, the rest recumbent on both the tergites and sternites. Leg scales dark leaden grey; hind tibiae with 4–5 long equidistant outstanding hairs. Antennae with relatively short segments, and densely clothed with long hairs. Palpi (fig. 4, *a*) relatively short and robust; 2nd segment rather densely clothed with very long hairs, the longest reaching to about the middle of the succeeding segment; 3rd strongly incrassate and about twice the length of the 2nd; 4th narrower, and a little shorter than the 3rd; 5th relatively very short and about equal in length to the 3rd. Clypeus very short, and widely rounded distally. Wings (fig. 4, *b*) narrowly lanceolate, and distinctly pointed; veins unusually thick; the 1st sub-marginal cell exceptionally small, and placed at a relatively long distance in advance of the tip of the 1st longitudinal vein, the distance

between the two forks of the 2nd longitudinal vein being five times as great as the length of the upper branch of the 2nd fork, hairs forming the fringe dense and of great length, some of them being much longer than the greatest width of the wing. The hairs and scales on all parts of the body are not, apparently, so easily deciduous as in other members of the genus.

Length, 1·6 mm, approximately; length of wing, 1·25 mm.

Gold Coast: Gambaga, in latrine, 1 ♀ (type), 1.vi.18 (*Dr. A. Ingram*).

Phlebotomus simillimus, Newstead.

Gold Coast: Yamalaga, 18.v.18, 1 ♂, 3 ♀♀; Kpalgu, 30.v.18, 1 ♂; Kukuma 6.viii.18, 1 ♂, 1 ♀; Maibindiga, on walls of Rest House, 31.v.18, 1 ♂; Nkoranza, 9.viii.18, 2 ♂♂, 10 ♀♀; Kulmasa, 22.vii.18, 1 ♀; Sekodumase, 5 ♀♀ Yeji, 8.viii.18,; 6.v.18, 1 ♂ (*Dr. A. Ingram*).

Phlebotomus walkeri, Newstead.

Phlebotomus walkeri, Newst., Bull. Ent. Res. v, p. 190 (1914).

Phlebotomus longipalpis, Newst. (*nec* Lutz & Neiva), *ibid.* p. 188.

The species taken by Dr. F. D. Walker on the Abuna River, Bolivia-Brazil Boundary, in 1913, and recorded by me in this Bulletin (*l.c.*) as *P. longipalpis*, Lutz & Neiva, is, as I surmised at the time, clearly distinct and, so far as I can judge, must take specific rank under the alternative name, *walkeri*, suggested by me (*l.c.*).

The males of the two species are easily separable by the characters of the external genitalia: in *P. longipalpis* the small brushes or peniculi are absent, and the four long spines on the distal segment of the superior claspers are arranged as follows: one apical, one sub-apical, and the remaining two placed closely together on opposite sides of the segment in a similar way to the corresponding spines in *P. sergenti* (see fig. 2, *b*); whereas in *P. walkeri* the 4th spine is quite isolated from the others.

I am pleased to be able to clear up the discrepancies to which I had previously called attention, thanks to the generosity of Dr. Lutz, who has very kindly presented me with examples of his *P. longipalpis*.

Phlebotomus sp.

The examples recorded below come very near *P. antennatus*, Newst., and possibly represent a degree of variation in the antennal formula of the females of this species. But pairs taken in coitu are needed before one can state to what extent variation occurs in the females of this and other allied species.

Gold Coast: Yeji, 6.v.18, 1 ♀; Savelugu, in Rest House, 25.v.18, 1 ♀; Wa, on walls of Rest House, 20.vii.18, 1 ♀; Navarro, on walls of M.O.'s quarters, 22.vi.18, 2 ♀♀; Kwaman, 10.viii.18, 3 ♀♀; Yamalaga, 18.v.18, 2 ♀♀; Salaga, on walls of M.O.'s quarters, 10.v.18, 1 ♀ (*Dr. A. Ingram*).

Phlebotomus sp.

Mesopotamia: Amara, x.18, 1 ♀ (at light); 8.ix.18, 1 ♀ (at light); Amara, River Tigris, 30.ix.18, 1 ♀ (*Capt. P. A. Buxton*).

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st July and 30th September, 1920, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. E. Ballard, Government Entomologist, Madras :—1 Tachinid fly, 17 Coleoptera, and 28 Lepidoptera ; from South India.

Captain P. J. Barraud, Entomologist to the Egyptian Expeditionary Force :—235 Culicidae, 1 *Phlebotomus*, 7 Tabanidae, 1 Hippoboscid, 84 other Diptera, 39 Hymenoptera, 69 Coleoptera, 2 Planipennia, 13 Lepidoptera, 5 Isoptera, 18 Rhynchota, 6 Orthoptera, 34 Odonata, and 1 Tick ; from Palestine.

Mr. John R. Bovell, Superintendent of Agriculture :—3 Diptera, 22 Hymenoptera, 2 Coleoptera, 6 Lepidoptera, 4 Thysanoptera, 9 Isoptera, and 15 Mites ; from Barbados.

Dr. Brünn, Jewish Health Bureau :—A series of insects affecting *Cuscuta* ; from Palestine.

Mr. P. A. Buxton :—315 Orthoptera ; from Mesopotamia.

Mr. P. R. Dupont, Curator of the Botanic Station :—3 Diptera, 21 Ants, 1 Moth, 1 species of Coccidae, and 100 Mites ; from Seychelles.

Mr. T. B. Fletcher, Imperial Entomologist, India :—134 packages of Coccidae ; from India.

Mr. G. F. Hill, Entomologist, Australian Institute of Tropical Medicine :—17 Culicidae, 8 *Tabanus*, 4 other Diptera, 3 species of Coccidae, and 3 other Rhynchota ; from North Queensland.

Mr. M. Afzal Hussain, Government Entomologist, Punjab :—21 Diptera ; from the Punjab.

Mr. J. C. Hutson, Government Entomologist :—28 Coleoptera, 47 Lepidoptera, 25 Rhynchota, and 470 Ticks ; from Ceylon.

Dr. J. F. Illingworth :—188 Hymenoptera ; from Queensland.

Dr. W. A. Lamborn :—41 Culicidae, 17 other Diptera, 3 Moths, 27 Lepidopterous puparia, and 236 Chalcids ; from Nyasaland.

Dr. Ll. Lloyd :—3 tubes of Aleurodidae ; from Herts.

Dr. R. E. McConnell :—13 Tabanidae, 244 *Glossina*, 3 *Stomoxys*, 13 other Diptera, 12 Hymenoptera, 27 Coleoptera, 14 Rhynchota, and 7 Orthoptera ; from Uganda.

Prof. G. H. F. Nuttall, F.R.S. :—7 *Tabanus*, 62 Hippoboscidae, and 100 early stages, 20 other Diptera, 54 Coleoptera, 2 Hymenoptera, 4 Rhynchota, and 2 Anoplura ; from various localities.

The Rev. Father J. A. O'Neil, S.J. :—75 Coleoptera and 13 Moths ; from Rhodesia.

Mr. A. W. J. Pomeroy, Government Entomologist :—6 *Tabanus*, 34 other Diptera, 25 Chalcids, 40 other Hymenoptera, 78 Coleoptera, 34 Lepidoptera, 36 Rhynchota, and 4 Planipennia ; from Southern Nigeria.

Mr. A. H. Ritchie :—1 species of Coccidae ; from Jamaica.

Senhor A. F. de Seabra :—37 Coleoptera ; from San Thomé.

Mr. Hubert W. Simmonds :—5 Diptera, 3 Lepidoptera, 1 Lace-wing, and 8 Chalcids ; from Polynesia.

Mr. S. H. Skaife, Government Entomologist :—2 Diptera and 34 Coleoptera ; from Natal.

Mr. R. Swainson-Hall :—2 Beetle larvae ; from Portuguese East Africa.

Mr. O. H. Swezey, Entomologist to the Hawaiian Sugar Planters' Association :—9 Coleoptera, and 11 Rhynchota ; from Hawaii.

Mr. Robert Veitch :—54 Diptera, 140 Chalcids, 16 other Hymenoptera, 1,440 Coleoptera, 85 Lepidoptera, 1 Caddis-fly, 72 Rhynchota, 4 Orthoptera, and 1 *Chrysopa* : from Fiji.

Wellcome Bureau of Scientific Research :—15 Tabanidae, 22 other Diptera, 2 Hymenoptera, and 7 Rhynchota ; from various localities.

Mr. R. O. Williams, Superintendent of Agriculture, Grenada :—Material of leaf blister mites ; from Carriacou and Isle d'Rhonde.

AN EXAMINATION OF THE TSETSE PROBLEM IN NORTH MOSSURISE, PORTUGUESE EAST AFRICA.

By C. F. M. Swynnerton, F.L.S.

(Plates IX–XVII and Map.)

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I.—Introduction.

In June 1918, I arranged to carry out a preliminary investigation of the habits and distribution of the tsetse-flies in the northern portion of the Mossurise district for a maximum period of three months on the understanding that the Mozambique Company would defray the general expenses of the expedition.

After a brief stay at Gogoyo's with little success I proceeded to the country east of the Sitatonga Hills. I had found tsetses in considerable numbers there in June 1900, and hoped by commencing my work in a well infested area to gain at once a thorough acquaintance with the fly that would stand me in good stead during the rest of my expedition and enable me also to decide quickly on my requirements in the matter of bait and labour. I was fortunate enough to make a number of particularly interesting observations during this first part of my trip, east of the Sitatongas.

Having found that the large tsetse (*Glossina brevipalpis*) does not come readily to man or to goats, I applied for cattle to serve as bait. These reached me on

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28th July, and proved quite invaluable during the remaining six weeks. They revealed abundant fly in places in which the nature of the vegetation had previously been the only indication of its possible presence, and led to the suggestion that one reason why investigators have commonly met with so enormous a preponderance of male flies is that insufficiently attractive bait has been offered to the sex that comes only to feed.

The part of my investigation already referred to, east of the Sitatonga Hills, was carried out with the help of my own farm natives only, and was concerned chiefly with the small flies, *Glossina morsitans* and *G. pallidipes*, which I there found mixed. I also then made my discovery, and commenced my study, of the Mtshanedzi-Buzi *brevipalpis* area, which at its other end affects Spungabera.

The second month (I was now being assisted in the matter of labour by Snr. Lanne) was occupied mainly with a fly survey of the northern part of the district. It included also the completion of my work on the breeding habits of *G. morsitans* and a week's study, south-west of Chibabava, of a typical piece of the surface-basalt country that constitutes so very large a proportion of the low-lying parts of the Mossurise district. At this period I sent a successful side-expedition round north of the entire Lusitu River in the Moribane district in order to gain some idea of the full extent and importance of the eastern fly-areas.

The third section of the trip was occupied with the completion of the above work, with experiments directed to ascertaining the effect and cost of particular forms of clearing for fly, a study of the habits of *G. brevipalpis* and a special study of the Spungabera problem. Spungabera being the official head-quarters of the district, and the seat of a herd of cattle belonging to the Mozambique Company that had lost heavily from trypanosomiasis, its protection from fly appeared to be of the first importance.

I returned home finally on 10th September, and afterwards I sent a small expedition to the Chinyika River, south of Spungabera, and completed my breeding experiments.

Four days had been spent near the British border examining the details of nagana outbreaks in Portuguese territory, two in trying to ascertain the maximum dry season elevation of *G. brevipalpis*, and two in all at Spungabera itself. Otherwise all the work was more or less far within Portuguese territory. I had had four working camps—one on the Umvuazi River east of the Sitatongas, one on the Buzi in the Gunye-Umpombo country south-west of Chibabava, one near the east end of the great southern *brevipalpis* area, and one at its west end at a point on the Buzi six miles from Spungabera.

The Mossurise fly problem quickly proved to be of quite extraordinary interest. Apart from the presence in the district of so many different tsetses, and the opportunity of studying them usefully that is offered by the very varied but well-demarcated conditions of vegetation, elevation, rock-formation, etc., that the district affords, the area west of the Sitatonga Hills was, under the Zulu domination, the scene of a particularly fine experiment in the banishment of tsetse. It was not difficult to obtain the details of this experiment, as most of the older natives had, incidentally or by compulsion, taken part in it. I made particular efforts to obtain information on this point, (*a*) because a study of any successful campaign,

by whomsoever carried out, is bound to add usefully to our general knowledge on the subject of controlling tsetse ; (*b*) because the area cleared of fly was the very area which, in the Mossurise district, is best adapted to white settlement. This experiment affords a very clear indication that settlement, properly planned, is itself capable of clearing the country settled of the two flies here concerned *G. brevipalpis* and *G. pallidipes*.

Other points to which I paid particular attention were an analysis of the vegetation in relation to tsetse, and a study of the distribution and local behaviour of the dangerous and less dangerous woodland types. The practical study of tsetse is, I am convinced, a matter for the botanist and œcologist rather than the unaided entomologist, and this point will be seen to be of the first importance. Each of the tsetses is dependent on particular, but different, shade conditions. Without a clear knowledge (*a*) of the woodland types that provide these conditions, (*b*) of those that provide them throughout the year, and (*c*) of the dry season response of each of these types to elevational and edaphic conditions, exceptional seasons, burning, etc., any clearing operations that may be undertaken in the future for the extirpation of fly, in connection with settlement or otherwise, will be lacking completely in the elements of precision and economy.

The main practical results have been, I think, the clear defining of the several fly-areas and of the situation at Spungabera, the lessons, both general and in relation to future settlement in Mossurise, to be drawn from the details of Umzila's success, and, in relation to *G. brevipalpis* in particular, the fact that the annual grass-fires can be made to play an important part by regulation of the time of burning. In primary forest the control of this fly is unfortunately rendered difficult by the presence of the *Landolphia* vines, which it may not be wished to sacrifice.

So far as *G. morsitans* is concerned, it seems to me that the possibility of taking advantage of its highly gregarious and localised habits is worthy of further study.

I conclude by expressing my very high indebtedness to Snr. Lanne and, in his absence, Snr. A. P. Monteiro for going out of their way to do all in their power to assist me in making a success of the investigation, and to my old friend Snr. Ferreira for his very cordial offer of help on learning that I was working in his district also. I am likewise particularly highly indebted to Dr. W. T. Lawrence of Gogoyo, who not only gave me such information as he already possessed with regard to the fly and continuously collected tsetses for me locally, but also rendered my work east of the Sitatongas and south of the Mtshanedzi possible in this foodless season by lending me native food in considerable quantity. Mrs. Lawrence most kindly presented me with gauze for nets at a moment when it was particularly acceptable, and Messrs. J. W. Scott and G. D. Otterson, living in the mountains, were good enough to assist me in a test of the resistance of *G. morsitans* to cold in the pupal stage. For some of the literature of the subject, presented to me at different periods in the expressed hope that I would undertake tsetse investigation, I am indebted to my friends Drs. G. A. K. Marshall and A. G. Bagshawe, Directors of the Imperial Bureau of Entomology and the Tropical Diseases Bureau, London, respectively ; and for copies of his own interesting publications, to Mr. R. W. Jack, Rhodesian Government Entomologist. I have also to thank the Rhodesia Museum and Mr F. P. Mennell, of Bulawayo, for the latter's identifications of a rock collection

made in connection with the tsetse work ; Mr. E. C. Chubb, Curator of the Durban Museum, for his identification, still incomplete, of the small mammals trapped by me in a dry season breeding centre of *G. morsitans* ; and the Director of Mines, Maçequeçe, for his kind loan of the Geological Survey Report. Mr. W. M. Longden, who spent many months with the Chief Gungunyana, has kindly sent me many interesting notes on Manikusa's and Umzila's wars.

Lastly, I have to thank His Excellency the Governor of the Mozambique Company's Territory for his sympathetic interest in the undertaking, and the readiness with which he provided for the expenses of the expedition.

II.—Nature of the Country Investigated.

The country investigated lies chiefly in the Mossurise but partly in the Moribane district, and in the main between the Buzi and Lusitu Rivers. East of the latter river's great southward bend it is bounded by the southern termination of the splendid Chimanimani massif with peaks of over 8,000 feet, and by that of the Mabiti highlands. Its most prominent physical feature is the straight, high, narrow Sitatonga Ridge that, pointing to the magnetic north, cuts at right angles to the two rivers and effectively shuts off the lowland plains east of it from the foot-hill and valley country to its west. The latter is divided further by two rivers, the Mtshanedzi and the Puizisi, which flow out from the direction of the political border, but turn off, the former to the Buzi, the latter to the Lusitu, shortly before reaching the Sitatongas. The valleys are low and broad, as is that flanking the Sitatongas on that side, and it was these valleys that were the site of the guard-area employed by Umzila for the protection of the enclosed country—a successful measure against fly which I shall describe below.

Between the Lusitu and Puizisi, between the latter and the Mtshanedzi, and again between the Mtshanedzi and the Buzi, are three hill systems, the first two backed by and rising strongly to the highlands of the British frontier (*see* Map), the other consisting of independent second-rate heights rising from broken country that falls away gradually to the eastward-flowing Buzi.

The elevation varies from well over 4,000 feet (1,220 metres) on Mount Umtareni and the Sitatonga crests, and 3,700 at Spungabera, to 2,000 and 1,000 feet and less in the lower valleys between the Sitatongas and the British border. East of the Sitatongas the general elevation would be nearer 500 to 600 feet. Indirectly at any rate, elevation is an important factor here in relation to the permanent distribution of tsetse.

I had no means of taking altitudes, but the following aneroid readings, taken by him in 1917, have very kindly been given me by Mr. R. W. Jack.

Inyamadzi River, on British border	2,200 feet	(679 metres)
Lusitu River, near British border	1,300 ,,	(396 ,,)
Lusitu, near Haroni Junction	1,100 ,,	(335 ,,)
Mossurise River on Spungabera-Masanjena Road	950 ,,	(290 ,,)
Gogoyo, Dysart Concession	1,200 ,,	(366 ,,)
Mtobe's Kraal	about 1,000 ,,	(305 ,,)
Mafusi's Kraal	2,200 ,,	(670 ,,)
Spungabera	3,700 ,,	(1,137 ,,)
Jersey homestead	2,800 ,,	(853 ,,)

The last figure, though obtained in British territory, gives an idea of the higher altitudes in the lower part of Gwenzi's country, about the Chinyika River south of Spungabera.

III.—Wooding of the District Analysed.*

A classification of woodland types in relation to tsetse would properly be founded on the degree to which and the length of period during which they lose their leaves in winter. It so happens that the division between evergreen (or with high, dense, heavy undergrowth and lianas) and deciduous coincides here in the main with the natural division of the wooding into two principal types.

These are :—(1) primary forest, pyrophobic or fire-fearing, dominated either by evergreen or deciduous trees ; (2) secondary, pyrophytic or fire-supporting forest of various sub-types. The latter replaces the former where that is burnt out. Bark adaptations enable it to withstand fires, and it is burnt through annually. Where it so thickens up as to reduce the grass growth, and consequently the severity of the fires, it tends to be re-invaded by the primary forest. A large proportion of the finer rubber forest in the area investigated consisted of secondary forest in course of re-invasion, and this harboured the large tsetse (*Glossina brevipalpis*).

Primary forest (Pl. ix ; Pl. xiii, fig. 2) consists of lofty, densely growing trees that support many woody lianas and shade lower tiers of evergreen shrubs and small trees, with a carpet and fringe that do not readily burn. Primary forest of the "rain-forest" type exists in the highlands, mostly in small patches at Spungabera and elsewhere, and is characterised by such splendid trees as *Khaya nyasica* (East African mahogany or mubaba), *Chrysophyllum fulvum* (large muchanja) and *Piptadenia buchanani* (umfomoti). The last-named species dominates most forest of this type seen in the Lusitu-Sitatonga rubber country. It gives it almost the character of "monsoon" forest, for it differs from the others in being regularly deciduous ; but the period of leaflessness is not very long, and the lianas and high close-packed evergreen shrubs (Pl. xiii, fig. 2) continue to afford the requisite shade for the forest fly, *G. brevipalpis*, and to favour its activities at all hours of the day.

There is much striking evidence in favour of the view that primary forest once covered this country, and that during very many thousands of years past it has gradually been reduced to its present small dimensions through the agency of burning and cultivating man. From this and from the analogy of the distribution of our other forest animals, quite apart from the results of the movements of game, would follow the comforting deduction that primary forests that to-day lack the large tsetse possess some advantage, elevational or otherwise, in regard to it, and are likely therefore never to harbour it for long. Such forests are those of Spungabera, Mount Silinda and the border generally.

Apparent primary forest here has three sub-types, "mountain," "heavy" and "ravine." The first does not concern us; the second (Pl. ix) is characterised by the shrubs, *Conopharyngia usambarensis* and *Dracaena fragrans*, and the liana,

*These descriptions of woodland types are necessarily greatly condensed, but their recognition will be facilitated by reference to the accompanying illustrations.

Landolphia swynnertonii; and the third (specially common in the area investigated) is often dominated by the *Piptadenia*, by the shrubs, *Craterispermum laurinum* and *Dracaena gazensis*, and the liana, *Landolphia kirkii* (*cf.* Pl. xiii, fig. 2). It seems to be the most important in relation to *G. brevipalpis*, though I have also taken this fly in some numbers in the heavier type.

A river-bank association that is worth mentioning specially owing to its ubiquity is that which consists mainly of tall, clean-stemmed trees of mowana (*Adina microcephala*) and mubaba (*Khaya nyasica*) growing on the immediate edge of streams and, so long as the moisture supply remains ample, resisting the action of the fires. Except where it has been associated with lower woody growth, I have not found it to harbour fly. However, it frequently is thus associated.

Secondary formations—deciduous in varying degrees—present several very clearly defined sub-types varying from savannah to close wooding, and each somewhat closely confined to a particular geological formation. With "wooded pasture" of one or other of these sub-types it covers the bulk of the country.

The local "formations" are as follows:—

(1). *Very highly deciduous types*, such as *Pterocarpus sericeus* (mumbhungu), *Pterocarpus angolensis* (bloodwood or mubvangazi)—the earliest shedder and latest reclother of all (Pl. x, fig. 1)—*Acacia natalitia* (ihlofunga), *A. caffra* (iguwha), *Bridelia micrantha* (mushungunu) and others. Considerable stretches of country are covered almost exclusively with bush of these species—open or dense, pure or mixed. Fly spreads in during the rains, but I failed completely to find tsetse in wooding purely of this type during the leafless period even in such shade as there was, and as it is quite unlikely that they can exist there then, it follows that such areas are cleared each year for from one or two to many months at a time. The country carrying these more sensitive types of wooding is characterised by good soil and permanent streams, and much of it by high elevation. It is particularly suited to settlement.

(2). *Lowland bush savannah* (Pl. x, fig. 2), comprising many tree species, but with the mupoza (*Combretum* near *leonense*) dominant on the drier parts and the musekesa (*Bauhinia reticulata*) on those that are wetter in the rains. The bush is mostly sparse and, the fires being early and the trees and shrubs low, the shade is destroyed at an early date in a normal year. Rare scattered fly, *G. morsitans* and *pallidipes*, was to be found in this type of country up to the time of burning, that is in 1918 the end of July, but permanent fly was near by in a more suitable type of wooding—*Brachystegia*, with vleis. I found no trace of the existence of permanent breeding centres in this type of country—the basalt.

(3). *Brachystegia wooding*, here known as "tondo-bush" or "itondo" and evidently identical with what Jack calls "gusu." This again contains a variety of trees and shrubs, but different species of *Brachystegia* dominate, such as *B. globiflora*, the mutondo (which gives its native name to the type of wooding), and the mutsatsas, *B. randii*, *B. bragaei* and *B. spicaeformis*, the trees of the red spring foliage. *Uapaca* also—*U. kirkiana* (munjanje) especially in the highlands, *U. sansibarica* (mutongoro) below—is common and in many places forms pure wooding. *Diplorhynchus mossambicensis* (mutowa), with its weeping

foliage, creviced stem and branches and furrowed, protectively coloured bark, is a particularly useful tree to the tsetse and is abundant in *Brachystegia* bush at low elevations. It is the foreground tree in Pl. xvi, fig. 1.

Tondo-bush is the tsetse bush *par excellence*. *Brachystegia-Uapaca* wooding in our present connection is divisible into three varieties, two of which carry each its own tsetse. It is divisible into (*a*) high "itondo," characterized by the greater size of the trees and generally denser wooding and forming fine "savannah" forest (Pl. xvi, fig. 1); (*b*) lower, more open "itondo," still mostly savannah forest, but poorer and intermixed with more definite savannah (Pl. xv, fig. 1). It is (with other conditions correct) the special haunt of *G. morsitans*. The former, finer variety is divisible further into (1) clean itondo, devoid of woody undergrowth and of the large fly (Pl. xiii, fig. 1), and (2) itondo with woody undergrowth, inhabited by *G. brevipalpis* (Pl. xii, fig. 2).

This undergrowth, usually patchy, consists for the most part of saplings of the trees themselves, often in close-packed clumps (Pl. xii, fig. 2; Pl. xvi, fig. 1), and of large scattered shrubs such as the umtunduluku (*Ximenia americana*) and the chigwenderes (*Bauhinia galpini* and *B. petersiana*); but in parts of the high itondo may be found numerous clumps of "ravine" type primary forest undergrowth, extensive or small, of bird and baboon-carried genera that have made a start and maintained themselves where the ill-regulated fires have enabled them to do so. Pl. xiv, fig. 1, gives some idea of their nature.

Two highly important points about itondo in relation to tsetses are these:—(*a*) The grass-growth in general below high tondo-bush is sparser than in some of our other secondary sub-types and does not burn really effectively till late in the season; (*b*) itondo as a whole, under our local conditions of rainfall, tends to retain its leaves through the winter better than any other of our secondary formations. The mutsatsas (*Brachystegia bragaei*, etc.) have often regained their leaves before the associated mutondo trees (*B. globiflora*) have lost theirs, and the Uapacas only lose theirs (and that not completely) when nearly all the other species are busy regaining their leaves. This tendency to keep in leaf without some slight interregnum is less marked at high elevations, in particularly cold and dry winters, and in the drier parts of the lowland areas; but on the Buzi, and in the "Oblong" (see Map) generally, it was sufficient in 1918 to carry *G. brevipalpis* in numbers everywhere through the winter, and it is probable that in most if not all years it would do so in most parts of this piece of wooding.

(4). *Dense secondary forest* includes especially (*a*) the very fine type of wooding dominated by musara and musunganyemba (*Milletia stuhlmanni* and *Pteleopsis myrtifolia*)—definite "monsoon forest"; and (*b*) a more mixed type. In places, owing often to the coppicing effect of unthorough native cultivation with the good seed-bed offered by old gardens to seeds from the surrounding bush, and to the relative exclusion of fire consequent on the absence of grass, the ordinary trees of the savannah form more or less dense thickets (Pl. xvii, fig. 1). Eventually trees and shrubs that are normally found on the outskirts of primary forest introduce themselves and finally dominate. Such are the munjerenshe (*Albizzia fastigiata chirindensis*), the large umkadhlo (*Rauwolfia inebrians*) and the fine shrubs *Vernonia*

podocoma (mudambasese) and *Brachylaena rhodesiana* (ipahla). The annually burning grasses tend to disappear, the live carpet may become sparse or it may become composed in part of the non-burning grasses that occur in the primary forest of the same locality. Clumps and stretches of the handsome ribbon-like izeya grass (*Setaria mauritiana*), beloved of buffalos, also of *Amomum* (good shade for *brevipalpis*) are exceedingly common, and thickets occur of such tall, more or less herbaceous plants as *Isoglossa mossambicensis* and the unpleasantly smelling *Mellera lobulata*. Woody undergrowth is usually more or less scarce excepting when the wooding is under invasion by primary elements.

In the simple coppice stages (Pl. xvii, fig. 1) these woods are highly attractive to *G. pallidipes*; in the older stages where the overwood is tall and heavy, as on the Sitatonga base, and some underwood is present, they shelter *G. brevipalpis*. In the Mtshanezi-Puizisi area especially a large proportion of the groves of this type are of relatively low growth and are characterized by the presence of the very beautiful climbing fern, *Lygodium subalatum*, which carpets the ground and curtains the trunks up to a considerable height, affording low shelter and additional shade where the shrub growth is poor. This variety of the type is perhaps more commonly frequented by *pallidipes* than by *brevipalpis*. "Dense mixed secondary" occurs here chiefly on the dolerite and, like *Milletia* bush, tends readily to be replaced by primary elements (which are more suitable to *brevipalpis*) where it is in contact with them. Thus *Albizzia chirindensis* and *Piptadenia buchanani* (umfomoti) are at present sharing the dominance of the Mafusi rubber forest, and the shrub growth shaded by them is already largely primary. The musara (*Milletia*) is rather specially deciduous, and I have found relatively little dry season fly in this variety of dense secondary excepting where it was under incipient primary invasion.

(5). *Bauhinia and Erythroxylon-Landolphia thickets.* Two species of chigwendere (*Bauhinia galpini* and *B. petersiana*), large and densely foliaged shrubs that lose their butterfly-shaped leaves more or less late in the season, occur from the British border to the Sitatonga Hills. *B. petersiana* continues to be present east of the hills. They are found in every type of secondary wooding, especially on ant-heaps, but in places they form almost pure coppice of their own. When well-grown and in leaf, their coppice is more attractive to *G. pallidipes*. Where, however, the Bauhinias occur isolated under higher shade, *G. brevipalpis* is attracted and rests under their coils—for under these conditions they tend to assume the habit of lianas.

Low dense thickets of *Erythroxylon emarginatum*, *Pleuroridgea zanguebarica* and other erect shrubs, with a few rubber vines, have invaded (for the most part) *Pterocarpus* wooding at high elevations on Mount Umtareni. I found no fly there, for reasons probably of elevation and also of situation; for between this and the permanent fly-bush (*Brachystegia*) lower down the slopes lay a belt of highly deciduous trees (formation 1, above). Lowland rubber forest (Pl. xi) is not essentially different. It also contains much of the *Erythroxylon*, but the invasion of *Landolphia* and other lianas has progressed further than on Umtareni and here fills the thickets. The trees of the highly deciduous and other (*Brachystegia*) types that have been invaded still in many places stand out above the new shrub growth, just as on Umtareni. I refer particularly to the Madanda forests, which I did not

visit on this trip, but which (from what I saw of them in 1906–7) I should quite suspect of being capable of harbouring *G. pallidipes* and, in many places, *G. brevipalpis*.

IV.—Factors Influencing Leaf-fall.

I have described above the *relative* deciduousness of our various types of bush. We have seen that primary forest (Pl. ix), and bush which it is seriously invading, is never leafless enough here to discourage its special fly—*brevipalpis*; and that of the secondary types, *Brachystegia* wooding (Pl. xvi, fig. 1) and particular varieties of the "dense secondary" formation tend to retain in this district sufficient leaf to carry fly through the year.

However, within any particular type of wooding actual leaf-fall is hastened locally, and the gaining of the leaf correspondingly deferred, by several factors. It is true that some of the differences are apparently individual, though unseen root disabilities might account for them. It is at any rate of frequent occurrence to see two trees of the same species and size (*e.g.* of *Pterocarpus*) standing together, one of them leafless the other not. *Ficus subcalcarata* (the mutowetowe fig, an isolated large specimen of which will sometimes harbour fly) is an extraordinarily erratic leaf-shedder. But general rules are apparent also.

(1). Season affects leaf-fall. After the abnormally heavy rains of 1917–1918 (2,514·5 mm. at Spungabera) leaf-fall generally took place, I should say, quite three weeks later than usual, where frost was absent. A low rainfall (such as that of 1913), or early and severe cold, hastens the phenomenon. It must be remembered further that rainfall, hence leaf-fall, varies with locality, particularly in relation to the mountain ranges. The rainfall appears to be distinctly lower east of the Sitatongas than on them or even west of them, and is lower here again than on the hills of Spungabera, the "Jihu" (Gwenzi's) and the British border.

(2). Proximity of moisture in the soil affects leaf-fall in two opposite ways. On damp low-lying ground liable to frost the leaf-fall is hastened, and even where there is no actual frost, trees bordering on ill-drained, cold, swampy ground tend annually to lose their leaves earlier than those of the same species that stand back on well-drained soil. But trees standing on warm, damp soil lose their leaves later than the latter. These differences are to be clearly seen in fly-harbouring *Brachystegia* woods, but the particular illustration I shall quote is concerned with some scattered wooding of *Pterocarpus angolensis* (mubvangazi—Pl. x, fig. 1) that is under my continuous observation. Here not only is there, in May, an increased leaflessness as one approaches the cold, damp lower valleys, but of the trees within the latter, those with their roots raised on ant-heaps are practically in full leaf when those on the general ground-level are completely leafless.

(3). Differences in the amount of humus present has appeared to account for a difference in leaf-fall between woods of the same species—*e.g.* of *Pterocarpus sericeus* (mumbhungu) on the dolerite—and it is to be noted that ant-heaps exert an influence in this direction also. It is probably again mainly a matter of relative moisture retention.

(4). Geological formation affects leaf-fall once more on the same lines. I have noticed that *Pterocarpus sericeus* loses its leaves a good deal later on the fertile

(and moisture retaining) upland dolerite than on the sandstone-shale formation at the same elevation. The *Brachystegia-Burkea* groves of the far drier, deeply cracking, compact basalt soils of the plains, effectively drained by the low-flowing Buzi and highly insolated, were losing their leaves earlier than those of the granite, especially on stony outcrops ; while similar wooding on a quartzite strip on the Buzi, at the same elevation and distance from the river and only half a mile away, was far later than the latter, as was the *Brachystegia* wooding (doubtless with better rainfall, however) of the sedimentary area of the higher Buzi.

(5). Altitude, other things being equal, makes a difference. Travelling between Maruma and the escarpment at Makwiana's kraal on 11th August I saw no *Albizzia* (munjerenshe) or other secondary wooding that was not completely leafless. On approaching the foot of the descent I began to find some in leaf—and at once found fly, both *brevipalpis* and *pallidipes*. I have come across many other examples both in our individual tree-species and in our woodland types that were thus reminiscent of the instance of the plane tree—simultaneously leafless at Innsbruck, yellow-leafed at Garda, dark green at Palermo and in parts of Greece evergreen ; and I have little doubt that latitude must also count for much in this connection.

Altogether it is certain that no unqualified statement disregarding rainfall, soil-moisture, frosts, elevation, latitude and exceptional seasons can be made for particular types of wooding as regards the period for which they will be without leaves and inhospitable to tsetse. It is, I think, equally certain that an exhaustive study of these factors may be of great assistance not merely in the explanation of local outbreaks, but in the actual control of the fly. Certainly no investigator can at present lay down the law for another area than his own as to the behaviour of particular types of wooding and, therefore, for the seasonal behaviour there of the fly.

A point that cannot be too greatly emphasised is that, if we are to fight the fly economically as well as effectively, we must base our measures not on the normal but on the exceptional season. I do not refer to the season that is so exceptional as to occur only once in 50 years—as the great droughts of 1860 (approximately) and 1913 ; nor to cases in which haste is vital ; but, let us say, to the driest or coldest season in ten.

The effect of the factors that I have mentioned above may be seen even when leaf-fall has been brought about artificially, as by a fire.

V.—Effect of the Annual Grass-fires.

These very commonly anticipate leaf-fall. Except in the loftier bush, and to some extent there, they scorch and wither even the higher leaves and defoliate the saplings and shrubs, destroying the shade. The very factors, local and seasonal, that accelerate or retard the date of the normal leaf-fall hasten or postpone that of the fires also. In 1918—except on the uplands where the frosts were considerable and dried the grass—the earlier fires were a month or more later than usual ; in 1913 they were exceptionally early (after a deficient rainfall) and provided some excellent instances of what might be accomplished by severer annual fires towards the destruction of tsetse-haunted bush. The Buzi flats with their cracking basalt

soil (Pl. x, fig. 2) are stated always to burn earlier than the granite gneiss near them (Pl. xiv, fig. 2; Pl. xv, fig. 1) with its impervious underlying bed, and the sandstone-shale areas of the uplands west of Spungabera definitely do burn considerably earlier than the dolerite beside them. The type of bush also influences the date of burning. High canopy-forming *Brachystegia*, such as occurs in Mossurise on the upper Buzi, burns effectively much later than the same bush where it is lower and more broken, and some types (as high dense secondary, including *Milletia*) burn, if at all, late yet tamely.

It is stated that under the Zulus burning was the subject of regulation for hunting purposes, a late, thorough burn being aimed at and usually achieved. Under the white man everyone burns when he pleases. It thus comes about that the first fires take place when the grass is but half ready to burn and there is relatively little recent leaf-litter on the ground. They attract but little wind to swirl the flames into the tree-tops and the thickets, and they are very small in extent, so that the flies driven from them find ample refuge all round. When later fires take place—at various dates—the areas burned earlier are already becoming fit for the reception of the fly and the latter suffers no inconvenience. A still worse effect of unregulated burning, from the point of view of tsetse control, is the encouragement given by too early burning to the wooding and particularly to the formation of the thickets on which *G. brevipalpis* rather specially depends (Pl. xvii, fig. 2). Late burning on the other hand finds the grass and fallen leaves at their driest and most abundant, and is so extensive as to draw in great wind. It achieves much actual destruction of young growth, and a temporary destruction of much high shade as well, at a hot, dry time that must be relatively critical for the tsetse.

A failure to burn, again, may be made the means of destroying thicket growth if the next year's burning is late, owing to the additional amount of inflammable material present. The fire no longer stops at the outskirts. This result actually followed the temporary effort to keep fires from the rubber forests, and I was shown where pieces of these forests (in Umtobi's country—of the type shown in Pl. xiii, fig. 2) were completely destroyed in consequence.

VI.—Distribution of Rocks, Woodland Types, Food Animals and Fly.

Geological Formations.

Geologically, the country investigated is divisible into four clear-cut blocks, two of them east of the Sitatongas, two west. The two to their east are a granite-gneiss and a basalt formation. The two to their west are (*a*) a sedimentary formation of shale, sandstone and quartzite; (*b*) dolerite, breaking through and capping the sedimentary formation, which in the dolerite area is visible only in places.

The *granite-gneiss country* consists of lowland plains, flat to undulating.* It is bounded on the west by the Sitatongas, on the north (I believe) by the Mabiti hills across the Lusitu and by their north-easterly continuation, on the south by a fairly well demarcated line a few miles south of the Umvuazi and apparently

*My rocks, identified by Mr. Mennell as mica granite, gneissose granite and Muscovite granite or gneiss, show more or less foliation, and the area appears to be that, east of the Sitatongas, described by Theile and Wilson as metamorphic. The general characteristics are those of the granite.

following the same general direction as that river. The surface soil is a coarse, loose, whitish sand, and numerous vleis, still wet in the dry season, indicate the presence below of the usual impermeable layer.

The *basalt plains* (Pl. x, fig. 2) adjoin the granite-gneiss on its south. They cross the Buzi and cover a great extent of country to the south of it. The ground, reddish where the rock is exposed, browner or blacker in the interleaved alluvial patches, dries rapidly after the rains and shrinks and gapes. In the country actually investigated by me it is possible that the Buzi, flowing between fairly high banks, determines the height of the water-table.

The *sedimentary area*—or rather the area where this stratum is continuously exposed, for it underlies both the basalt and the dolerite—fills the great oblong tract enclosed between the Mtshanedzi and Buzi rivers (see Map). A broad strip of the same formation runs thence up the Buzi to the British border. It is hilly throughout, the soils are mostly compact, and the rock frequently outcrops. Except in the strip just referred to, it is not well supplied with permanent streams.

The *sub-ophitic dolerite*, as dyke or cap, dominates largely between the Mtshanedzi and the Lusitu, and especially at and south of Spungabera in Gwenzi's country. It is accompanied by a red, rather clayey, yet well drained and highly fertile, typical "trap" soil, and abounds in excellent permanent streams.

The Sitatongas themselves are of quartzite, flanked by schists, trap, etc.; apparently (Thiele and Wilson) the schists dominate to the north of them, in the area traversed by my native expedition.

Distribution of Woodland Types.

The granite-gneiss carries open (mixed) *Brachystegia* bush usually of a rather poor type (Pl. xiv, fig. 2). Its vleis are nearly bare of wooding, except for the fine trees on the ant-heaps that stud both vleis and dry land. The finer vleis in particular are lined by a short green sedge (*Fuirena*). The male tsetses are found in rather special connection with this.

The basalt, as might be expected from the above description, tends to carry a very poor type of bushy (Pl. x, fig. 2), mixed, but commonly more or less stunted and very open woods—the "lowland bush savannah" of my classification (p. 320). Thorn groves occur in places; elsewhere, on exposed or nearly exposed sedimentary rock, *Brachystegia* patches. The grass, short in some places, is long in others. Fires are earlier here than anywhere else.

The sedimentary rock of the "Oblong" and its northward extension carries itondo (*Brachystegia-Uapaca* forest) of a particularly fine type, with a good deal of sapling undergrowth and, in places, patches of invading primary shrub formation (*v.* p. 320 and the figures there referred to). The mutongoro (*Uapaca sansibarica*) often forms close groves beside vleis. The grass growth is seldom dense or very high, except in open places (Pl. xiii, fig. 1), but great and annoying burr areas, of four semi-herbaceous species of *Triumfetta* (dzunzu), occur. They dry up and are leafless in the winter.

The dolerite carries (*a*) wooding of the dense mixed secondary types, largely composed of highly deciduous species, and including *Bauhinia* thickets; (*b*) open

Pterocarpus sericeus (mumbhungu) wooding, highly deciduous. It is also, however, the chief seat of the surviving primary forest (Pl. ix; Pl, xiii, fig. 2). A high-forest area composed of primary forest (largely ravine type), tall, dense, mixed secondary, and invasions of the latter by primary forest, covers much of the broad strip of country that comprises the Mafusi and Maronga rubber forests, and stretches interruptedly from somewhat near the British border at beacons 76–77 eastwards to the Musapa, crossing the Lusitu on the way. It is roughly bounded on the south by the Puizisi, but sends two broken, narrow extensions southwards along the eastern and western base respectively of the Sitatongas. Between the Puizisi and the Mtshanedzi, and again in the Gwenzi country, lighter dense secondary types dominate, copse-like groves (Pl. xvii, fig.1), and fern-entwined wooding alternating with open, highly deciduous wooding of *Pterocarpus sericeus* and its *Acacia* and other associates. This more open wooding dominates rather specially at the higher elevations, though scattered close *Albizzia* groves, losing their leaves in the cold weather, are also somewhat prominent there. Narrow primary-type thickets —fringing forests (Pl. xiv, fig. 1)—often occur along the small streams, and harbour fly permanently at the lower elevations. The grass-jungle growth, except in the dense wooding, is immense and tangled. The fires are normally more or less late and, when postponed further till the grass is dust-dry, they are of extraordinary severity.

Distribution of the Game.

This again is most simply stated in terms of rock-formation. The lower-lying Mtobi-Gogoyo dolerite-dyke country that is bounded by the Mtshanedzi on the south, the lower Chikambwe on the west, the Mtobi piece of the Lusitu on the north, and the Sitatongas in the east, forms an area that is poorly stocked with game, and is surrounded by the heavily stocked areas of the gneiss, basalt, sedimentary rock and (latterly) the higher elevation dolerite. Of these well-stocked areas the basalt only (Gunye's, etc.) is somewhat unattractive to the buffalos, though they wander into it in small parties in the rains. Their distribution is chain-like, the new buffalo colonies of the dolerite connecting occasionally with the herds of the sedimentary " Oblong," these with the herds of the Umvuazi–Lusitu *Brachystegia-morsitans* area (the gneiss), these with further herds in the Moribane district (at Muchamba's, etc.), and these again, it is said, with those of Cheringoma. With them are found elands and elephants in numbers, animals that are also rather specially attracted by *Brachystegia* bush, yet have latterly invaded the dolerite also.

Bush-pigs are exceedingly and increasingly abundant on the sedimentary rock and the dolerite, far less so on the gneiss and basalt, where they are largely replaced by wart-hogs. Herds of sable antelope are distributed through the country generally. Lichtenstein hartebeests are present in numbers throughout the two formations east of the Sitatongas, also (but much less so) on the sedimentary rock, but not at all on the dolerite with its jungly grass-growth. Waterbucks occur in small herds on the large rivers. Bushbucks, reedbucks and duikers are present throughout, where the conditions are suitable, and little blue duikers (*Cephalophus monticola*) are in some numbers in the dense forests and thickets.

Baboons are abundant everywhere, especially perhaps in the Sitatongas, in the mountains of Spungabera and parts of the British border, and in the dense Lusitu wooding. The forest monkey, *Cercopithecus albogularis beirensis*, is to be found wherever high dense forest is present, and the bush monkey, *C. pygerythrus*, is ubiquitous, in smallish numbers.

Distribution of other potential Hosts of Tsetses.

I shall refer sufficiently to man and the smallest mammals below under "Food of the Fly." But facts to be referred to also, and particularly Lloyd's results from his examinations of the gut-contents of *G. morsitans*, show that in considering the fly's dependence on the local game population we cannot leave out of account the local bird and reptile population. Guineafowls and francolins, the former particularly, both crested and horned (*Guttera edouardi* and *Numida mitrata*), are everywhere abundant, the crested guineafowl especially frequenting dense forest. Of doves, all ground-feeders, two of five common species occur in dense forest, three throughout the other woodland types. Each of these two main woodland divisions boasts also its own considerable low-searching insectivorous bird population and its common touraco. The smaller seed-eaters—waxbills, whydahs, weavers, canaries—are a very important item in the bird population everywhere except in dense forest, and even there (as I noticed in the Madanda) in the open spaces that are covered with grasses that burn. They are nearly always found on or near the ground, and commonly in great flocks. They are most abundant in the non-forested, heavily seeding dolerite areas—with less permanent fly. Quails were seen everywhere in grass-country and much on the borders of the *morsitans* vleis.

Another bird that haunts every type of woodland and has been recorded as being attacked by tsetses (Lloyd) is the ground hornbill (*Bucorax cafer*), purely a ground-searcher. It walks in small spread-out parties and (in common with the insectivorous birds) makes up somewhat for any lack of numbers by adopting a definite beat, most parts of which it revisits at intervals of a few days. In common with them also it probably does the fly more harm than good, for it destroys many snakes and the young of ground-nesting birds. Secretary birds and the various storks may be classed with it in this respect and are found in rather special association with the two formations about to be mentioned.

The water-haunting birds are found mainly on the basalt (on the Buzi) and granite-gneiss. Jacanas, egrets, bitterns, hammerheads, moorhens, rails, grebes, and occasional herons are found at the larger pools of the vleis of the latter formation, constantly but in small numbers and in contact with some of the dry season centres of *G. morsitans*. The two largest rivers and such fine series of pools as those east of Chibabava boast a far larger water and waterside population, but, so far as I have seen, it does not come into really intimate and essential contact anywhere with the main tsetse populations. The ground-running birds—the various bustards and coursers, dikkops, sandpipers, plovers, etc.—are particularly addicted for many spring and summer months to the shorter-grassed and sparingly wooded basalt, and certainly also to the granite-gneiss, though I have not seen them there when the grass has been recently burnt.

The main reptile-population follows closely the two biggest rivers and is not sufficiently intimately connected with the big permanent fly-belts to be worth discussing. In the fly areas I noticed more snakes, including several puff-adders, on the granite-gneiss than elsewhere. Other reptiles were a large arboreal *Varanus*, which occurs in various types of secondary wooding, including *Brachystegia*, but of which I have seen few individuals in all, and some not very abundant Agamid and smaller lizards in the *Brachystegia* areas.

Distribution of the Fly in relation to the Geological Formation.

The granite-gneiss, with its open-stemmed *Brachystegia* covering and frequent vleis, is the special home of *G. morsitans*, which in the dry season is still to be found in numbers and breeding actively beside particular vleis. *G. pallidipes* is also plentiful there, and *G. brevipalpis* is found in small numbers where the shade is particularly heavy.

The basalt, with its sparse stunted bush, was still carrying an extremely thin sprinkling of *G. morsitans* and *pallidipes* in late July, when burning was barely beginning. I am inclined to regard it as, in the main, an overflow area from the gneiss, and it is quite likely that any measures that banished fly from the latter formation would incidentally banish it from the adjoining basalt.

The sedimentary rock area, with its fine *Brachystegia* forest and considerable if patchy undergrowth, is apparently more or less heavily infested almost throughout with *G. brevipalpis*. *G. pallidipes* also occurs, but in small numbers, said to be greater in the rains.

Of the two woodland sections of the dolerite area the Mafusi-Musapa high-forest section, with its extensions, appears to be more or less heavily infested throughout, at any rate in the dry season, with *G. brevipalpis*, *G. pallidipes* also occurring. Pupae of *G. austeni* were taken in numbers near the Buzi-Mtshanedzi confluence.

In the Puizisi-Mtshanedzi area on the other hand *G. pallidipes*, though in small numbers seems rather specially in prominence, perhaps in part owing to the relative absence of the bigger fly. The latter does occur here and there in small numbers wherever the shade is suitable. Behind the Makwiana escarpment the country appeared to be clear of the fly by early August and had probably been so for some weeks, though it would still doubtless be possible occasionally to encounter there an odd straggler carried from below, particularly on the Chikambwe's tributaries, where leaf was present. At the lower elevations, where also the bush of the dolerite retained more leaf, fly was still met with; but judging from the observations that Dr. Lawrence has most kindly carried out for me since my departure, it would seem that it must become specially scarce there also towards the close of the dry season, though not extinct. It is in part a matter of leaf-fall, for at his station (Gogoyo) *pallidipes* showed itself once more in some numbers with other biting flies when the leaves were well in evidence again in the hot weather shortly preceding the rains. *Glossina brevipalpis* was taken in small numbers here and was seen by me also on the Buzi below Spungabera.

An expedition sent by me to the Chinvika in late September failed to take any tsetses, though it brought back numbers of other biting flies.

There are three great permanent fly-areas in the country investigated :—(1) The *morsitans-pallidipes* area of the granite-gneiss ; (2) the *brevipalpis* area of the Lusitu rubber forests ; (3) the *brevipalpis* area of the " Oblong."

Between the last two is sandwiched an area of more deciduous foliage. Out of the higher parts of this such fly as has got there is ousted in the cold weather by the leaf-fall, and in its lower parts the fly becomes scarcer and more localised before the rains, reappearing with the leaf in October. These last remarks refer to *G. brevipalpis* and *pallidipes*, the latter fly occurring throughout the area.

Finally, there is a narrow strip along some of the frontier, widest at Spungabera and on the hill-mass enclosed by the Puizisi-Muchamba confluence, that may be regarded as quite fly-free, excepting in so far as travelling parties of male flies may on occasions be carried into it during the rains and early dry season by buffalos, etc. Nearly all the country on the British side of the frontier may be regarded as falling within this category.

G. austeni was taken only near the junction of the Buzi and Mtshanedzi. The type of wooding in which it occurred is not uncommon on lowland streams, and there can be little doubt that further investigation will show it to have a more extended local range.

More generally it may be concluded that each fly is confined closely to particular woodland types, which, in turn, are confined to particular geological formations, the conditions that suit *pallidipes* being the most widely distributed. But the distribution of the permanent fly is by no means thus conterminous with that of either the buffalos, the big game generally, or any particular species of mammal, though abundant mammalian life of some kind is present in each of the areas, fly-carrying or otherwise. Man is relatively scarce (except on the Lusitu), and very small mammals are abundant everywhere in the fly area. The dominant bird elements of the *brevipalpis* areas are insectivorous and gallinaceous. The *morsitans* area has in addition a stronger bustard-plover element and, at some of the permanent fly centres, a very limited water-bird element, as well (apparently) as a somewhat larger reptilian population than the other areas. I may add that various moth larvae, numerous, gregarious and often immense, are much more in evidence in *Brachystegia* areas than elsewhere ; but, for reasons to be stated, it is doubtful in spite of Roubaud's results whether they are of great use to the fly. The fact that *brevipalpis* does not come readily to man makes its presence difficult to detect unless one is lucky enough to come across a male queue some evening. However, my conclusion that the " Oblong " was well infested was come to after I had seen only two flies. Their hum in flying struck me as being identical with a sound I had been hearing continually since I came there. I then made a point of disturbing all large flies of any species I saw and made my natives bring me for a day or two all they could catch for release close to me, but I failed completely to match the sound, which I therefore concluded to be that of *G. brevipalpis*. I continued to hear it, often on the part of large flies which I could not then identify visually that came out to us and turned back, evidently rejecting us, and of flies that flew away from the shady sides of tree-trunks when these were beaten. An observation on pigs of a day or two later and subsequent results from cattle abundantly justified the conclusion.

VII.—Umzila's Experiments in Close Settlement.

Earlier History of the District.

About ninety years ago, following immediately on the invasion of Bulindhlela or lower Gazaland (the Delagoa-Inyambane country) by the Zulu chief Manikusa, what are now the Mossurise and South Melsetter districts became the scene of three invasions. First came that of "the Bulindhlela chiefs, who, though defeated by Manikusa, refused to submit to him. . . . They retired in a north-westerly direction, over-ran this country, seized all cattle (then plentiful) and later proceeded north to Matoko's." Secondly, these fugitives were "followed by Unćaba (*alias* Mosani) as far as Chiamiti—now the farm Schaapplaats in South Melsetter. Here Unćaba and his people settled." Unćaba was a brother of Manikusa's father, Isigode, and he and his people were part of the Zulu invading force under Manikusa.

"Unćaba became unpopular here, one of the principal grievances being that he would not allow members of his crack regiment, the Amakanda, to marry until their heads were grey. Representations were made to Manikusa and he was induced to come up here. Fighting occurred and Unćaba, forsaken by his best fighting regiment (the Amakanda) retired with a following up the Sabi valley, and subsequently in a north-westerly direction" (letter from Mr. W. M. Longden). I do not know whether the view is correct that this "impi" founded the "Angoni" tribe near Lake Nyasa.

Manikusa (who returned to lower Gazaland) died in 1861. His second son, Umzila, disputed the claim of his elder brother, Mawewe, to the throne and, at first defeated by him, went north and settled in succession at Umpombo's on the Buzi, and Dongonda north of the Lusitu (see Map). Mawewe eventually followed him thither, but was defeated with the aid of the Portuguese, and Umzila took possession of lower Gazaland. He himself remained at his northern capital, which he shifted more than once. From Dongonda he moved to Gandwa, on what is now the writer's farm "Gungunyana" in South Melsetter, and thence, later, to the neighbourhood of the Chinyika River in Gwenzi's country, south of Spungabera. Here he made his longest stay, eventually moving to Mwayamuhle's, just south of the Mossurise in Garawha's country; and here he died.

His son Gungunyana shifted the headquarters across the Mossurise to the foot of Mount Singuno, but later, in about 1889, he returned to the old southern capital Bileni, near Lourenço Marques. The population of Mossurise and South Melsetter was forcibly collected and taken thither. Soon after—in 1895—the Portuguese Government had to bring Gungunyana to account, and with his capture in the following January (Theale), the Zulu native domination ended. Since then the Mossurise natives have gradually drifted back from Bileni to their old homes, but it is stated on all hands that only a small proportion actually has come back, and that the population of the district does not at all approach its former size.

In 1893, the land on the British side of the border was occupied and settled by Europeans, that on the Portuguese side, in part depopulated of natives as I have stated, remaining wild to this day. In 1896–7 the rinderpest swept through the country and, missing small areas here and there, decimated not merely cattle, but in particular buffalos, kudus and elands.

Fly and Cattle before Umzila's Time (say 1820–1861).

There can be little doubt that ever since the arrival of the Bantus particular pieces of country have been subject to local concentrations of population, and that where other circumstances have been sufficiently favourable, these concentrations have resulted, while they lasted, in the opening-up to cattle-farming of the piece of country involved.

The " old people " had told my various native informants that previous to Unċaba's massacres of about 1830, farming went on successfully even close to the Sitatongas, where they had shown them the old cattle pits. The country was very densely settled. The chiefs Mafusi and Mtobe have both told me that at that time cattle were kept in those portions of their countries in which all subsequent attempts to keep them have failed, and Gunye has stated that it had been handed down that in the days before Unċaba cattle-farming, accompanying a concentrated population, took place even in his country, but that many used to die. But when Umzila came here (in 1861) the whole country had reverted to wooding and game as the result of the depopulation arising from Unċaba's massacres. It was much as it is now; fly had become plentiful, and the mountains of the present political border were the boundary, then as now, between the fly and such cattle as existed.

Umzila's Experiments (1861–1889).

Both when at Umpombo's, and later at Dongonda, Umzila made a determined attempt to keep cattle, but in each case he failed. The concentration of population was not so great as in his later attempts; it was short-lived, and close by was a great belt of *G. morsitans*—a fly which follows man.

The Zulus, it may be mentioned here, knew the fly well, and the disease caused by it, and they regarded the proximity of game as dangerous for cattle. But why did they place their cattle amongst the fly? They said, " this whole country is full of it—where *shall* we put our cattle ?" However, cattle had always thriven in the open hilly country which is now South Melsetter; they were being captured at this time (after Umzila's defeat of his brother) in great numbers in raids on the Mashonas, and Umzila at last sent them all to Gandwa. Later he said " I cannot live away from my cattle," and it was thus he left Dongonda.

From Gandwa, Umzila sent an order to *sondela enkosini* (draw near to the King). Thereupon an immense compulsory movement of the population took place. The country to the east of the Sitatonga Hills, particularly in and south of Gunye's, was at that time more fully populated than that to their west, but almost the whole of this population was deported, territorial chieftains and all, to the lower parts of the tract between the Sitatongas and the present British border, to Spungabera and Gwenzi's country, and (with Umzila's further movements) to the Umswirizwi (Mossurise) valley, to Zinyumbo's Hills and Chimbiya's, and even eventually to the Sabi east of this area. The chief Gunye told me that he himself was compelled to settle at Chimbiya's.

The Effect on the Wooding.

Every one of my informants has described most graphically the result of this concentration. The bush simply disappeared and the country became bare, except

for the numberless native villages and a continuity of native gardens. This complete clearing was confined to the lower-lying areas. The Puizisi-Mtshanedzi hill-mass, as Makwiana told me himself, was relatively little affected by the new settlement, and the bush was never at all completely cleared. It was, however, surrounded on three sides by a broad cleared cordon, and on the other, backed by the highlands.

In Mtobe's and Mafusi's the bush was never fully cleared; the rubber forests already existed and they continued to do so, although, according to Mafusi and others, they then consisted merely of umfomoti wooding (*Piptadenia*) that was chiefly confined to the ravines. In Gungunyana's time they had already spread greatly (under encouragement), and many *Landolphia* vines existed throughout the new areas not yet wrist-thick. They were a valuable asset to the Zulus, who traded the rubber for cloth on the coast, and used the latter in turn in the barter of cattle. Again, away from the neighbourhood of the Mtshanedzi and the Buzi the "Oblong" remained completely uninhabited and uncleared.

Zinyumbo's area, like Gogoyo's, was very completely cleared—"right to the Mwangezi it was gardens only," as was Gwenzi's country, the Mossurise valley and portions of the Sabi.

The Effect on the Game.

Large mammals became very scarce—not merely big game, but pigs and baboons. "The Mangoni (Zulus) are killers of everything, men and animals." Drives with nets were organized across the entire country, and game, pigs and baboons were thus killed wholesale. If a herd of buffalos was reported subsequently anywhere west of the Sitatongas, it was at once hunted; if pigs appeared in a garden, they were at once tracked down to their retreat, and, the people round having been called out, were surrounded and killed. Except on its fringes the "Oblong," then as now, was a great uninhabited game reserve. The game in it was thinned, it is true, and was kept well driven within its borders, but there still remained enough to attract the Mangoni hunting parties. In the heavily settled areas a few bush-bucks, duikers and pigs were still to be found throughout the period.

The Effect on the Tsetses.

There were still plenty of int-hesi (tsetse) in the tondo-bush on the granite-gneiss, and fly never disappeared in the "Oblong." In neither place could cattle ever be kept. In Mtebe's country too and the eastern part of Mafusi's—that is, within a short distance of rubber forest—they could never keep cattle. Mafusi told me that he remembered the fly there, with the same distribution as now, from the time he was a child, except that it has spread with the spread of the forest. At Maronga's and beyond—that is, in the continuation eastward across the Lusitu of the rubber forests—cattle could never be kept, though Usele and other Zulus settled there and made the attempt. In such places the cattle required for ceremonial purposes used to be brought, as needed, from the safe areas. Cattle also continued to fail in Gunye's country and south of the Buzi from the Mwangezi eastwards, though persistent and prolonged attempts were made to keep them in this area of sparse fly, the losses in some cases being made up time after time from outside.

In Zinyumbo's hills and even just on the Mwangezi cattle succeeded, as they did thence westward through the Mossurise valley and northward to Spungabera. This tract was full of cattle. But few deaths took place, and these always along its extreme eastern margin, on the borders of the "Oblong."

In the Gogoyo-Makwiana tract cattle were kept right under the Sitatongas both at and opposite the Rupisi and from the great bend of the Mtshanedzi to its source, also in the hills behind the cleared guard-area between the Mtshanedzi and Puizisi and up to and beyond the present British border. Many of the herds were large.

On the Sabi (present British territory) the results were particularly interesting, for this had previously constituted a separate fly-belt, which was eventually almost completely wiped out by native cultivation. The rinderpest may have given the *coup de grâce* to the surviving remnant or two (recent events render this doubtful), but at any rate cattle were already being placed and kept successfully all over the old fly area in the seven years between Gungunyana's departure (with all the cattle he could take) and the advent of the rinderpest (W. M. Longden and others).

When the country was closely settled, cattle were kept successfully in places where they had always died before; and when the settlement was well established, they succeeded where in its earlier days they failed, though fluctuations still took place with successive shifting of the population. It is true that herds actually abutting on the fly still suffered small and occasional losses, as they are doing to-day to a greater extent on the present fly boundary.

What drove the Fly out?

From the failure throughout the 25 years or so of this experiment to keep cattle near the Mafusi rubber forests, well settled and well cleared of large mammals though they were, it is likely that it was not the mere destruction of its food supply that cleared the Zinyumbo, Gwenzi and Puizisi-Mtshanedzi areas of fly. We may compare also Mr. Pollard's statement with regard to the Munshi division of Northern Nigeria (Bull. Ent. Res. iii, 1912, p. 221). "It is interesting," he writes, "to note that the Munshis are great hunters and that they have practically destroyed all the wild game in their district, and yet, in spite of this, the trypanosomiasis of cattle and horses is rampant."

But the game does not merely feed the fly; it also carries it, each year, from the permanent fly-areas into the more deciduous areas adjoining them as soon as these have sufficiently regained their leaves. The heavy settlement of the broad river valleys and the base of the Sitatongas, by clearing the bush, not only rendered those areas themselves inhospitable to the fly, but also opposed a barrier to the passage of game, and so protected from the fly the large enclosed piece of chiefly deciduous bush behind the guard-area. Previous to the establishment of the guard-area it had been impossible to keep cattle in the area behind it, as it is now again impossible, and the broad guard-area itself, to judge from the descriptions of the bush cleared, had probably harboured even more permanent fly then than it does to-day. That the fly-population itself was diminished by the Zulu system of late burning is also by no means unlikely.

The case is most instructive and points the way for future measures. It must be remembered that the flies concerned—*brevipalpis* and *pallidipes*, especially the

former, which is more abundant—are not such great followers of man as is *morsitans*, and that the chance of success in such a case, without wholesale clearing of the bush, is greater than where *morsitans* is concerned. On the Sabi it was different. Here the permanent fly-bush itself was destroyed to a far greater extent and the fly in most parts exterminated.

Was the Experiment intentional ?

These concentrations of population round the King were not primarily fly-measures ; they took place whether the country was fly-infested or not. But their effect in fly-country was well known to the natives, and I was informed that Umzila entertained considerable hopes in relation to the keeping of cattle from his successive concentrations at Umpombo's, at Dongonda, and west of the Sitatongas. Success was attributed to the effect on the game rather than to that on the shade, and Umzila's measures against the game were stringent. His intention of colonising the " Oblong " was frustrated by the depredations of lions on the settlements placed there (*e.g.* in the Budu country), and there were difficulties connected with water and an immemorial and bloody feud with regard to the Dengaza tract between the chieftains Makwiana and Gogoyo ;* but he settled its borders very heavily and kept the game well driven within them by means of frequent hunts.

The Effect of the subsequent Depopulation.

Before Gungunyana carried off the population to Bileni (near Lourenço Marques) in about 1889, he had already commenced to protect the game. He had decreed *azi-zale* (let them multiply), and game had become more abundant both outside and inside the cattle-keeping areas. The guard-areas still opposed its passage into and out of these areas and no harm resulted to the cattle. When the population left, the game (in the words of my native informants) just " burst forth " (za-dabuka). At the same time the wooding was let loose and soon re-established itself throughout the previously settled country.

In a very few years (by 1896 according to native information) the fly had more or less regained its old wet season limit—not many miles east of the present political boundary—though the bush capable of supporting it was not then so ubiquitous as it is now. I myself lost a beast from fly on " Scott's Hope " (a Portuguese farm on the British border) in 1900, and a tsetse was taken south of Spungabera, on the tondo-covered hills west of the Buzi (spot shown on map), in the same year by Drs. Wilder and Lawrence.

The fly caused little trouble then, but two things have happened since—a progressive invasion of the upland dolerite (*a*) by the deciduous wooding, and (*b*)—more important still—by game of wandering species. Buffalos and elands especially, decimated by the rinderpest, are now extremely abundant, and having spread from the sedimentary area into the hills, wander much more frequently than they used to into the highlands. It is only in the last three years that buffalos have reached the Puizisi country in any numbers. They have there tapped another *brevipalpis* area, and the consequence has already been visible in the destruction of the cattle of the Muchamba-Puizisi valleys.

* Not that this was allowed to continue actively under Umzila. He decreed " There must be no more war. We are the only King (Si'nkosi sodwa) ! "

VIII.—The Food of the Fly.

Observations by numerous workers elsewhere have shown that tsetses living in contact with large reptilian and avian populations very freely utilise the former, and perhaps also the latter as food. Gut examinations even of *G. morsitans* have shown in some cases (Lloyd) a remarkable proportion of non-mammalian contents; the same fly has been seen to feed on the bare neck-wattles of an unconfined ground hornbill (also Lloyd); a case is on record (Ensor) in which a fly, "almost certainly *morsitans*," was observed through glasses trying to get under a perched hawk's wing; and in the Entebbe laboratory *Glossina palpalis* "fed readily on captive fowls, creeping under the wings to reach the poorly protected parts" (Bagshawe). It follows from this last and extraordinarily important observation (which does not surprise me when I remember that *morsitans* rather reminded me of *Olfersia* in its low poise and clever sidelong movements in response to attempts to catch it) that birds are not necessarily protected against tsetses by their armature of feathers, though many of them certainly are by their agility and insect-eating habits. Yet young birds, whether nestlings or runners both in the nest and for a time after leaving it, are defenceless—and abundant just when the fly is abundant. Also the fly (as met with on this trip) retires to rest later than do most diurnal birds, the latter being thus relatively unprotected from it during a very brief portion of each day when the fly is particularly active—but the bird (it must be admitted) less conspicuous.

Such facts, with the way in which birds, including ground hornbills, keep to definite beats, the whole of which they work every few days, and the fact that nearly the whole bird-population searches for its food and breeds either usually or very commonly within a few feet of the ground, the search being conducted with much bustle and conspicuousness on the part of the large combined parties of small birds, must be taken into account when we attempt to explain such cases as Umzila's failure to keep cattle near the then much smaller rubber forests (in spite of a great hunting population and a strenuous effort to exterminate game) and when we consider the question of destroying game to starve the fly. At the same time, so far as small birds are concerned, it seems to me that the fly's habit of choosing harmoniously coloured surfaces to rest on suggests that its effort will be to evade rather than attack them during their active hours and stages of existence. I feel also that the very striking connection between the fly's breeding habits and game must be given its full weight.

My own observations dealt only with mammals.

Mammals from the smaller Ungulates downwards.

The natives of the *morsitans* area were unanimous in their statement that tsetses feed freely on baboons, and that "wherever you find baboons you will also find fly." They gave me many instances in which baboons driven from their gardens had left numerous replete flies behind and others in which flies were attracted in numbers to baboons that were killed. Simpson's similar personal observations and native statements on the Gambia and Gold Coast will be recalled, as will Lamborn's indirect evidence. Monkeys (*Cercopithecus pygerythrus*, which lives in lower bush than *C. albogularis beirensis* and raids natives' gardens) were stated more rarely

to have done the same, and—an important statement if true—it was stated that replete tsetses were occasionally found where cane-rats (abundant in much of this country and very largely diurnal) had been many together.

Pigs were as universally incriminated as baboons, and here I obtained a quite excellent instance myself. In the "Oblong" (east end) in cloudy weather we walked right on to four bush-pigs sleeping. In their hasty rush they left the flies behind, and these streamed after them in great numbers and with quite a hum. We captured nearly twenty that through repletion could scarcely fly; all but one were *brevipalpis*, the exception being a *pallidipes*, and more than half were females. Austen records both *morsitans* and *brevipalpis* as feeding freely on wild pigs and quotes Dr. Hearsey's statement that *G. morsitans* was seen to settle literally in hundreds on the carcase of a wart-hog, behind which animal I also took these flies.

My indirect evidence of the value of such animals as pigs to the fly was also interesting. In a mile-wide patch of primary forest east of the Sitatongas, in which I saw much *brevipalpis*, both native information and a careful search for spoor showed that it could have been feeding on nothing but pigs, baboons and smaller fry. The same applies to a piece of high, dense, secondary forest on the western foot of the hills, into which according to the owner of a kraal on the spot (confirmed by the usual search for spoor) no big game had entered for some months. It also applied, I am certain, to much of the rubber forest area in which pigs and little blue duikers—and these only—are abundant. In one place a length of about 300 yards for a very great width was continuously turned up by the pigs and looked like a hoed plantation. It made me wonder whether one of the forest hogs (*Hylochaerus*) may not occur in these forests.

Finally, working for over a fortnight round my camp on the Buzi east of Spungabera, in an area in which game is relatively abundant, I made a special point of studying the daily spoor in relation to the distribution of *G. brevipalpis*. To sum up the result, there was a considerable area that I am certain was not entered by big game during my stay, or for some days before it. There was a smaller, inner area, immediately round certain kraals, that had probably not been visited by such animals for many weeks or months. In general the spoor showed much less movement of the big game now than in the wet season, yet the fly was equally present throughout, lurking in all the thickets to attack passing animals.

The only "passing animal" that showed a similar ubiquity was the bush-pig, and I was convinced from the evidence that the fly was living practically entirely on bush-pigs at the time of my visit. Man was not being attacked. My friend Mr. G. D. Otterson spent a few days with me here, and declared on leaving that the evidence of the fly's independence of the bigger game in the matter of food was a "complete eye-opener" to him.

I conclude from these observations that any attempt in north-west Mossurise to destroy the fly by starving it in its permanent haunts is doomed to failure if the bush-pigs, and perhaps the baboons also, are not destroyed; and the destruction of the pigs in this type of country is not easy.

Two species of lemur occur in the fly areas. The larger of these, *Galago crassicaudatus*, is abundant in most of the *brevipalpis* country and sleeps exposed (but perhaps protected by its fur) in the daytime. Bats, including the largish fruit-bat,

Epomophorus crypturus, are abundant, and insectivorous species were found sleeping in great numbers in hollow trees of *Sterculia triphaca* on the ant-heaps of vleis frequented by *G. morsitans* and *G. pallidipes*. Bushbucks and duikers are more or less common—and hard to exterminate. The little blue duiker (*Cephalophus monticola*), more or less abundant in thickets and dense forest, is less hard to reduce by fence-trapping. It has a habit of resting under logs and between tree-buttresses that might bring it into additional contact with the fly. It was one of the animals least liked by my carnivorous mammals. Of yet smaller mammals two species of *Tatera* came in great numbers to my traps at a spot where male clusters of *morsitans* were present all the time on the grass and females in the wooding (Pl. xiv, fig. 2). Lloyd has suggested that nocturnal mammals, including MURIDAE, are perhaps liable to the attack of tsetses owing to the latter's habit of resting in similar holes. I have myself taken *morsitans* puparia from holes made by animals in a bank, and noted that *brevipalpis* and *pallidipes* rest in holes in trees. Nevertheless, an argument exists against this view in the fact that some of the bats at any rate are very easily disturbed, and the part played by the small nocturnal mammals, including bats, needs far fuller testing than it has received. Species of *Arvicanthis*, *Otomys*, *Myosorex* and *Petrodromus* are largely diurnal, but their small relative size suggests both their ready perception and intolerance of the fly and their less ready detection by it.

Dassies or rock-rabbits (*Procavia*) may be of much use to the fly, but very locally and only in rocky places. I found them in the coarse quartzite rocks that form the crest of the Sitatongas and support *Brachystegia*; and I spent many hours with several workers trying to find wet season tsetse puparia in the humus under raised and overhanging rocks, but without success. I searched similarly in the Maruma forest, frequented by dassies, but Maruma, I judge, in spite of the outbreak of trypanosomiasis there, is seldom if ever reached by the fly.

The larger Ungulates.

I have thought it well to give prominence to the evidence favouring the view that the pigs, aided doubtless by the smaller buck and perhaps yet more by the baboons, will continue to support a fly population in parts of north Mossurise even if the larger game is banished. At the same time it goes without saying that the larger the permanent game population the greater will be that of the fly; and I obtained abundant indirect evidence that, as things stand now, the bigger ungulates present in the fly-areas are taking an important part in the feeding of the tsetse. As I shall describe elsewhere, I found numerous batches of puparia—mostly of *morsitans*, a few of *brevipalpis*—associated with spots where larger mammals had been lying down. Buffalos were incriminated the most frequently, but Lichtenstein hartebeests, wart-hogs and other species were concerned.

My finds of pupae in the *morsitans* area seemed rather to suggest a preference for the buffalo on the part of the fly. I found this definitely asserted by some of the natives and denied by others. My guide in the *morsitans* area, a very observant native, was particularly convinced of it. Questioned as to a connection between the two animals, he replied that one may find fly where there is no buffalo, but that where there is a choice it follows the buffalo. "The buck," he said, "are much

more restless under its attentions than the buffalo, the hartebeests especially keeping up their dance when tsetse are about them; so that the fly can feed more easily on the buffalo." Neave has already made a suggestion to this effect.

I shall discuss this subject further under the next heading. Elephants were stated by the natives to be attended by tsetses when the latter are numerous, and I took a male *brevipalpis* waiting on a much used elephant path. Roubaud and Bouet (referring to *G. longipalpis*) are both quoted as speaking of a special association between tsetses and the elephant and hippopotamus.

Man—and the Fly's Preferences.

Using cattle as I did, I obtained abundant and excellent evidence that *G. morsitans* and *G. pallidipes* attack these animals more readily than they attack man, that *G. morsitans* attacks man more readily than does *G. pallidipes*, and that the latter, in turn, attacks man far more readily than does *G. brevipalpis*. It constantly and everywhere happened that the carriers passed through a place without drawing fly and that the cattle coming just afterwards attracted many. A dozen to twenty carriers are more conspicuous than two or three head of cattle and their scent is overpoweringly stronger. Similarly I have seen a fly (*pallidipes*) on a leaf beside the path allow carriers to pass it unmolested and then at once fly out to my donkey. Another piece of evidence was afforded by a fly (*brevipalpis*) that I found perched on a projecting slab of shale in the path, facing away from me. I stopped short (about two yards away) and had the cattle (immediately behind me) turned into the grass. After about two minutes the fly flew back to me and, without alighting, returned to its perch. I then had the two cattle immediately brought up, the leading ox standing nearly level with me in the path. The fly shortly flew back again, first to myself, then, swerving off, to the ox, under which it at once settled and began to feed.

A point that struck me in the *morsitans* area was that whereas when we were digging for puparia there was often delay before a fly attacked us (one fly was actually seen watching on a tree-trunk for a time before it came), the cattle were attacked quickly.

Man is attacked by all these flies much more frequently in the rainy season, but the increased attacks are probably not more than proportionate to the great increase in the number of the flies at that time of year. Dr. Lawrence has sent me records of occasional attacks on natives at his homestead at Gogoyo's even by *brevipalpis*, and as for *morsitans* (no doubt in company with *pallidipes*), I was informed by the natives across the Sitatongas that they become at times unbearable, forcing every man to carry a leafy twig with which he continuously switches his back and shoulders. *G. pallidipes* (it is stated) also becomes a nuisance in places west of these hills.

Concerning the practical question, "if other sources of food were eliminated, could the tsetse still keep going with the aid of man?" it is certain from the observations of Lloyd, Maugham, Stephenson-Hamilton, myself and others that the tsetses would then attack man much more. Tsetses (as I have seen) constantly obtain full feeds from man and escape unscathed and, where the bush comes up to a village, so far from avoiding it, *morsitans* and *pallidipes*—but not *brevipalpis*—appear to become rather a nuisance.

It is doubtful whether *brevipalpis*, a relatively easily detected and easily caught fly, would readily adapt itself to man. With regard to *morsitans* it may be said that the conditions favouring its dry season centres would have to be present as well as the villages. I only saw one such apparent coincidence here, but there is no reason why it should not be common. The size of the human population and its effect on the bush when really large are further factors to be considered.

Of our fly areas here the "Oblong" is uninhabited and the higher Mafusi and *morsitans* areas are not thickly inhabited. I believe it is very different on the actual Lusitu, but there *brevipalpis* would be the fly permanently present.

I was myself bitten by *morsitans* far less than my natives, but this was presumably a matter of skin-colour and clothes; Mabuzana, living near the Mtshanedzi south of Gogoyo's, volunteered the information that tsetses were specially attracted by a black coat. I said "How do you know that?" "Because I have one!"

Perhaps more surprising than the preferences shown in relation to man are those shown with regard to his domestic animals. I had three female native goats with me throughout the trip and in about the fifth week added a male; and until I obtained cattle, about a week later still, I used these goats continuously for bait. They proved most unsatisfactory, and although they were occasionally bitten, I have little hesitation in saying that even man was much preferred to them both by *morsitans* and *pallidipes* and was not liked worse than they were by *brevipalpis*. Put ahead of the cattle they failed to draw fly where the cattle would draw many. A dog that was with me throughout the trip and still remains healthy was relatively little bitten. Healthy-looking native dogs and goats were present throughout the fly-areas and were stated to be much bitten in the rains. I regularly fed my flies on the goats and once they bit they fed fully, but a relative reluctance to bite was distinctly seen, and this reluctance extended to a sheep on which I fed the flies that I finally brought home with me. The relative reluctance shown by Dr. J. W. S. Macfie's flies to feed on guinea-pigs, dogs and cats is worth recalling, also the preference of Lloyd's flies for monkeys as against goats.

Experiments that I carried out on ASILIDAE showed that those flies possess graded preferences along the same lines as carnivorous vertebrate animals experimented on, so that there would be nothing extraordinary in the tsetses doing the same. Experiments on carnivorous animals, including lions, showed the following order of preference:—(1) Pig, wild and domestic; (2) beef (nearly equal to pig); bushbuck and sable antelope were liked very nearly as much; (3) goat, sheep, dog, man, blue duiker. These last were liked far less than (2). It seems probable from the evidence I obtained on this trip that the preferences of the tsetses I had to do with would follow much the same general lines.

ASILIDAE often attack the highly nauseous Acraeine butterflies and tsetses attack man, but their preferences are very real nevertheless, in view of the fact that after a feed they do not wait till hungry enough for *Acraea* or man before feeding again should anything better turn up. Lloyd and others have shown, and my own observations confirm them, that when there is nothing better to turn up, the fly will at last "occur in such quantities"—that is to man—"as to be a source of the greatest annoyance" (Maugham). At Kanyezi's vleis, with some game about

but buffalos absent, we saw a good deal of fly and were often attacked by " feeders " (as distinguished from " followers "). In the Masando vleis in 1900 with game temporarily very scarce and buffalos absent I was very greatly pestered. This time, in the same Masando vleis, with buffalos present, I found few flies, and at a series of vleis a few miles further east which the buffalos had just reached in numbers I found none, though the natives stated that they had been there in great quantities up till then. At first at these places I had not the cattle, and it was legitimate to suppose, as the natives did, and it was doubtless true of the males, that the tsetses were " away following the game." But the female fly is a feeder, and apparently follows little, and the cattle quickly showed that flies were present, but that they were being kept too well fed to show themselves to less acceptable man.

It is easy, understanding the working of the fly's preferences, to see that a failure to find non-mammalian blood in an examination of its blood-contents is quite compatible with the possibility that it might live on birds and reptiles were mammals removed.

It follows also from my observations on this expedition that the old idea that tsetses possess a preference for the buffalo may be perfectly correct, though it will show itself strongly only where, and while, buffalos are so abundant as to make the fly comparatively independent of less favoured food. The special enthusiasm I saw shown for an actual congener of the buffalo seems to be highly significant in this connection.

Unfortunately there would seem to be no very practical method of utilizing the flies' preferences except by using cattle to draw them out. With its favourites destroyed it will live well on the next best and so on. Arsenic-tolerant cattle, sufficiently saturated, might be worth experimenting with as bait.

Drinking of Water by Tsetses.

My flies frequently applied their proboscides to grass-stems put into the tube wet (to simulate the effect of dew), never to those inserted dry. My native informants on the Umvuazi agreed in asserting that they frequently saw tsetses in numbers " drinking " on the wet sand of the river in very hot weather. I have watched *Tabanus* on the wet mud of pig wallows at the Amanzimhlope head-waters with its proboscis in definite contact with the moisture, as were those of non-biting Muscid flies of several species that were also present, and this habit of drinking is a common one in hot weather on the part of both Diptera and butterflies. Kinghorn and Lloyd have both noticed tsetses at the edges of puddles ; Moiser obtained records of it from his natives, and saw his captive flies insert their proboscides into the wet soil of their bottles ; and Lloyd obtained the same result from moistened sponge and moistened blotting paper that I obtained from wet grass. Carpenter has gone further, for he has traced the presence of the liquid inside the fly. The point is not merely of importance in relation to the hot-weather needs of the fly ; it may also be important, it seems to me, in relation to the possibility of poisoning the highly localised male swarms of *G. morsitans* by spraying the grass they rest on.

Lloyd's positive results from slices of water-melon go to confirm Maugham's observations (under natural conditions) as to the sucking of vegetable juices. It is probably moisture rather than real nourishment that would thus be sought and obtained.

IX.—Distributors of the Fly.

Game not only helps (*a*) to feed the fly, and (*b*) to provide the trypanosome, but (*c*) it helps to distribute the fly, carrying it back each summer into the areas from which the fall of leaf had driven it.

That the fly does definitely spread at each rainy season, over the latter type of area is shown by native statements, by nagana outbreaks, and by my finding in the highly deciduous country a mudstained pupa-case of *G. brevipalpis*, one of our most shade-loving tsetses. That the fly wanders back into these areas partly without the aid of game is possible enough; but without their aid I doubt if it would have re-occupied much country by the time the leaf fell again. The tsetse is a distinctly sedentary insect, and throughout reminded me much of a tick, excelling it mainly in flying a little distance to its prey instead of waiting to be brushed off by it. This, with the details of some of the outbreaks of trypanosomiasis, the fact that tsetses actually do follow animals for long distances, and the cogent indirect evidence I shall refer to on page 358, support the view that the game is of the first importance to the redistribution of the fly.

Accepting the hypothesis, the most important point to note is that the fly's chief distributors will be by no means necessarily identical, in a given area, with its chief food animals. The individuals, pairs or herds of most of our antelopes have definite circumscribed haunts and grazing grounds that they keep to. In the case of bushbucks and duikers these are small, and parties of pigs also for long periods together rootle and depredate from particular lairs or lair-areas. Hartebeests also have relatively small beats, and herds of sable antelope and kudu have their permanent grazing grounds, larger than these others, though the kudu is sometimes a wanderer. Animals with this localised habit may be regarded as the fly's most reliable food-supply in its permanent haunts, even though some other animal may temporarily become more important through sheer numbers.

Elands, on the contrary, are great wanderers; elephants cover much ground; and the buffalo, if it is on the whole less of a wanderer individually, and in the matter of long purposeful "treks" than the eland, nevertheless covers, with its great herds, very large grazing grounds, is continually wandering back and forth between its various centres inside and out of the permanent fly-areas, and breaks up into parties and individuals that, to judge from the spoor, leave little ground in the general range unvisited in the rainy season. Also, as I shall show elsewhere, the buffalo more than any other animal has been increasing its numbers and range here at a great rate for many years past.

I believe then that these animals, and the buffalo in particular, are mainly responsible for the annual spread of the fly, and that so far as we are concerned, in and near Mossurise, our main grievance against the game is not so much that it feeds the fly (which would be fed and contaminated in any case by the pigs) but that it carries it far and wide in the rainy season and so brings it into contact with the cattle.

The effect of the difference in the travelling habits of the male and female flies must of course be duly taken into account.

X.—Effect of the Rinderpest.

The effect of the rinderpest is of practical importance in relation to the question of destroying the game to starve the fly.

In reply to my question, addressed to many natives, as to whether the fly became less after the rinderpest, I received two answers, one from south of the Lusitu, the other from north. It may be stated at once that both buffalo and fly are said to be much more abundant, and to have been so before the rinderpest, in the *Brachystegia* area north of the Lusitu than in that to its south (both of them on the gneiss and carrying both *morsitans* and *pallidipes*), so that the difference in the replies may perhaps be genuine.

The reply from the former area (from the countries of Muchamba, Usambai and Udombe) was that the rinderpest was followed for two seasons only by a definite reduction in the numbers of the fly. In the second of these seasons it was already more numerous, in the third season and subsequently it was as numerous as ever. The buffalos were still scarce, so that if this statement is correct and there were also any real connection between the rinderpest and the fly's reduction, one explanation might be that the fly had previously become specially dependent on the buffalo, owing to the latter's immense relative numbers, and took a season or two to adapt itself completely to the habits of the other larger mammals. Wart-hogs and baboons were stated to have been particularly abundant. Another explanation will be suggested below.

The answer I received from south of the Lusitu, in the fly-areas both east and west of the Sitatonga Hills, was that the rinderpest was followed by no noticeable reduction of the fly at all. One man stated on the contrary that they then bothered the natives terribly. Another made the quite sound suggestion that perhaps with their other food destroyed they attacked men more, so that, though fewer, they seemed as many as ever. All insisted that, though certain abundant species of game were killed off, plenty of other food remained, in the form of bush-pigs, wart-hogs, baboons and part of the larger game.

To the above evidence I am able to add a little of my own. In 1900 I passed with carriers through a portion of the *morsitans* fly-area. Hunting on 31st May and 1st June in and near the large wood and series of adjoining vleis called the "Mahloka" or "Masando" near the Umvuazi we were beset by very great numbers of tsetses, which also kept with us for considerable distances—far heavier attacks and "followings" than any I experienced in 1918. At that time buffalos were still exceedingly rare as the result of the rinderpest of four years before. I saw no trace whatever of them during that trip—a shooting trip—and local natives I have consulted have confirmed the fact of their absence. I have already mentioned the loss of a beast beyond the limits of the present fly in 1900, and the capture in the same year of a tsetse south of Spungabera, just inside the edge of the present permanent fly.

On the other hand, my information from north of the Lusitu, if reliable (it was given to the members of my native expedition thither, not to myself), certainly seems to suggest that in some fly-areas an effect may have been produced. The real, dense, busily breeding centres of a *morsitans* belt may in the dry season at

any rate and under certain local conditions, be exceedingly localised. It is a fact also that the two animals that I have suggested to be the fly's most important carriers are amongst the three that suffered worst from the rinderpest. It is possible, therefore, that the actual effect of the rinderpest in certain areas may have been not directly to starve the fly, but to confine it the year through to a far greater extent to its dry season centres by the destruction of its chief carriers. The narrowing in this way of the area tapped for food in the wet season might react also on the numbers of the fly. The suggestion is tentative and perhaps may not be borne out in the belts actually reduced, especially if man, a carrier of *morsitans*, was present in numbers, living or passing, about the dry season centres.

The failure of the rinderpest to destroy the fly here to any appreciable extent tells decisively against the view that the rinderpest blood was in some way poisonous to the fly—for all my informants agreed as to its severity everywhere, except in a portion of Makwiana's highlands. The animals sometimes died "whole herds together," and I myself can witness indirectly to the effect on the buffalos.

Its failure tells also against the hope that we may exterminate the fly in the Mossurise district by destroying the bigger game only.

XI.—Factors determining the Presence of Tsetses.

Shade and Undergrowth.

It would appear from the present and other observations that the fly must be protected from the drying effect of continuous sunlight either by a sufficient supply of shade, or by a readily accessible moisture supply, or by both; and that this, with food, is its primary desideratum.

Glossina brevipalpis, so far as I have seen (and I was with it for some weeks in all), relies very greatly indeed on shade and is rarely found away from fairly heavy shade. The requisite degree of shading is provided by wooding with leafy undergrowth. This may be either primary forest (in which the undergrowth is sometimes such as to give sufficient shelter alone (Pl. xiii, fig. 2) or secondary bush in leaf with thickets and sapling clumps below (Pl. xii, fig. 2). Of these types the primary forest (Pl. ix; Pl.xiii, fig. 2) and, in many places and most seasons, heavy *Brachystegia* bush are the best capable of carrying this tsetse through the dry season. It is not at all dependent on the presence of vleis, and I have found it waiting in all the thickets at some distance from water of any kind and in hot weather in September with the ground baked. It is true that it was in greater numbers near certain little streams than in the *Brachystegia* thickets, but (as results from the same type of forest away from streams appeared to show conclusively) this was only because those streams were lined with fringing forest of primary type.

So dependent does the fly appear to be on good shade that, except in the early morning, after sunset and on dull days, it will leave animals it is on as soon as they emerge from the shady bush into the sunlight. On dull and rainy days it will follow freely into the most open country and at high noon, so that the term "crepuscular," which has been applied to this fly, is not altogether justified by my observations. Thermometer readings taken at the same time in primary forest, primary forest with its undergrowth cleared, and, thirdly, in a sapling thicket in *Uapaca* wooding along-

side, were identical, yet *brevipalpis* had deserted the cleared piece (*v.* Expt. 1, p. 373). This, with a failure to take *brevipalpis* in some high, dark secondary wooding on the Sitatonga base, excepting at the occasional thickets, suggests that extra shade may not be the only advantage gained from thickets. Protection from drying winds, additional protection from the eyes of enemies (such as the thickets very definitely afford) and some advantage to the pupae are the three that occur to me, but I am convinced that shade is the chief consideration.

Glossina morsitans was found in a very different kind of country. It was very obviously far less dependent on good shade than *G. brevipalpis*, and I failed to find even stray individuals in the densest forest types—but the stray individuals taken were in any case very few. It occurs both on the granite-gneiss and the basalt of the lowlands, the latter usually with very poor bush indeed (*Combretum*, etc., Pl. x, fig. 2) and the former with savannah forest of a poorer type than that of the sedimentary area, though in each of these two it is *Brachystegia*. On the basalt and on most of the gneiss this fly occurred during my visits only as very rare individuals, and on the basalt and away from vleis only males were taken. The granite-gneiss, however, carries (as I have related) very numerous vleis, many of them with permanent water, and in spite of much painstaking search elsewhere, it was only at these vleis (and then only at some of them) that *morsitans* was found in great numbers together and its breeding going on with some vigour in the dry season.

Here the male flies occurred in the usual bands, containing in some cases at least a few hundred flies at a time on the short or shortish grass and sedge. They were sometimes out in the sunlight amongst or beyond the scattered chidsgwati shrubs and stunted Parinariums that separate the open vleis from the *Brachystegia* bush surrounding them, sometimes a little way in the *Brachystegia* bush itself, never very far from the vleis. Some of these vleis with well populated fly-pockets consisted of mere glades in the bush, in which there was now no definitely exposed water and in some of which, had I not dug, I would hardly have expected water; but bigger vleis were part of the general series to which they belonged, and even in the glades experimental digging always showed moisture near the surface and actual water not many feet below. Some places would be moist on the surface, especially in the early mornings, when dew also was present in such glades generally. The flies were found in rather special association with a low, heavily-headed sedge (*Fuirena*), with which I found the local natives had also learned to associate them. This remained green after the grasses generally were dry and, with one or two low-growing associates, covered considerable areas at the edges of certain vleis. Almost the only low-growing plant that was transpiring at the time of my visit, and doubtless cooler than the dried-up species, it possibly offered a greater certainty of the deposition of dew.

The stray flies, of which I took fewer of *morsitans* than of *pallidipes*, appeared (as I shall indicate for *pallidipes*) to be finding their way to the vleis and rivers by the end of July, with leaf-fall already producing a visible effect in dry areas and at the actual vlei-edges, which latter, however, were also coming back into leaf. The natives described to me the increase of the fly in the hot weather, its spread in the early rains and its abundance then at places where, even with game temporarily absent, one now found few or none. In general it would be difficult

to find a more fitting description of this *morsitans-pallidipes* area than has been given by Dr. Shircore of the "proclaimed area" of Lake Nyasa (Bull. Ent. Res. v, pp. 87 and 88); although, owing to the lateness of the season in 1918 and the fact that grass-fires had now barely begun, I am not in a position to judge of the completeness and duration of the stripping of the drier country of the stray fly of which I seemed to have seen the beginning. This type of wooding comes back into leaf again very readily after the weather has warmed up, and it possesses an early element in the mutsatsas. The return of the leaf does not await the rains and the country is sometimes already very shady when it is otherwise absolutely at its driest. The relative value of these two factors—shade and moisture—in relation to the fly's fresh redistribution should be interesting to study.*

I did not find that *G. morsitans* appeared to be at all dependent on the presence of undergrowth. The bush in which it occurred was for the most part devoid of such growth, though some of it was itself low. I may add here that in consequence of the very late fires of 1918, and of the fact that I worked the normally late-burning areas last, the whole investigation was carried out in unburned country (except for a few odd patches). Nevertheless I obtained no evidence in favour of the view, but much against it, that any of the flies concerned will live in open grass-country devoid of bush. Even the attacks of *morsitans* on the basalt were always in or beside shade, were it only that of a large shrub or a semi-leafless tree, and when noted definitely *resting*, either in my experimental net or in the field, this fly was always in the shade—under a log, on the shady side of a trunk, etc. A replete resting *morsitans* female that I disturbed repeatedly always settled again on the shady side of trees. I have seen waiting male clusters furthest from bush in large vleis, but there was some reason to suppose that the individual flies did not stay with the cluster indefinitely.

Glossina pallidipes is distinctly more catholic here in its general tastes than either of the other two. It occurs both in the country favoured by *brevipalpis* and avoided by *morsitans* and in that favoured by *morsitans* and avoided by *brevipalpis*, as well as in wooding of its own; nor do the stray individuals, at any rate, avoid the extremes. Males were taken on the sparsely shaded basalt (Pl. x, fig. 2) in dry windy weather and with the leaf falling freely, and occasional individuals of both sexes were taken in primary forest dominated by *Khaya nyasica* in full leaf (Pl. ix).

I do not feel that I disentangled its habits sufficiently from those of *G. morsitans* on the granite-gneiss. Here, in the *Brachystegia* bush, it appeared to occur in every place in which we found *morsitans* (Pl. xiv, fig. 2; Pl. xv, fig 1). It was in great numbers only where *morsitans* was also numerous—namely at particular vleis and glades; it was very sparse elsewhere, but less so than *morsitans*, and both flies (and once *brevipalpis* too) were on us or the cattle together. When *pallidipes* puparia were taken at all, they were under the same log as those of *morsitans*.

* Mrs. Lawrence, writing for her husband well on in November and sending me flies, speaks of the pleasant and cooling effects of the first light rains—"but" (she adds) "the tsetses! they are abundant." Tsetses had reappeared with the return of the shade, but the advent of the rains would seem to have led either to their freer breeding out or (as I think, by making more general the conditions under which they could exist in comfort or safety) to their freer dispersal from their breeding centres.

A fact that is possibly of interest is that in my first week spent at the Kanyezi *morsitans* centre (28th June–6th July) I saw and secured numbers of *morsitans* but relatively few *pallidipes*, though a good sprinkling of this fly was present. During my second stay there (27th July–1st August) *pallidipes* had apparently been heavily reinforced and was now taken (both males and females) in greater numbers than *morsitans*. It did not seem that emergences could account for this difference; the puparia, living and empty, taken in large numbers on each visit, contained an extraordinarily small proportion of those of *pallidipes*—perhaps one per cent.—though the bush generally was well searched. On the other hand the adult flies of both sexes, which at my first arrival were scattered more through the country generally, had latterly, with only two or three exceptions (these being on the basalt where moisture would be harder to find), been taken only at streams. There was a difference now in the fact that the country was drier, and that leaf-fall had commenced and was in places appreciable at the time of my second visit, so that the evidence suggested in a remarkable manner that *pallidipes*, previously to a larger extent scattered sparsely over the face of the *Brachystegia* area, had now congregated at the *morsitans* centres. It is perhaps difficult to disentangle this conclusion with certainty from the fact that the cattle always drew, and were now drawing, *pallidipes* in much larger numbers than natives working without them; but on this occasion the latter were themselves securing a larger proportion of *pallidipes* than previously. I should say that on the granite-gneiss the presence of *pallidipes* was in no way dependent on that of woody undergrowth.

West of the Sitatongas, where *morsitans* does not appear to occur at all, stray individuals of *pallidipes* were taken in very open bush—and in every type of bush—but it was never taken even two or three together except in *Brachystegia* and the less tall of the "dense secondary" types. It certainly occurs in small numbers in the dry season throughout the "Oblong" and its northward extension to the Buzi. It is even possible that this great *Brachystegia* block may be its main permanent habitat here, and it is notable that my cattle sustained a severe attack from *pallidipes* on 27th July in a limited piece of *Brachystegia* wooding just north of the Dysart Concession—a wood that had previously supplied a *pallidipes* or two daily to Dr. Lawrence's grass-cutters just outside it. I also took a few *pallidipes* between this station and Gogoyo's kraal at a series of small vleis in very dry sandy country carrying a type of *Brachystegia* bush equal only to the poorest on the granite-gneiss and already losing leaf somewhat heavily, and was informed by a native formerly resident that this fly was exceptionally bad here in the rains. Apart from these instances my only real and repeated successes with this species in the "Oblong" area were in and near the piece of coppice shown in Pl. xvii, fig. 1 and representing a type of wooding that, resulting from native cultivation, is more abundant north of the Mtshanedzi. Here (north of this river) on a few occasions up to half a dozen—even a dozen together showed themselves in such types as are illustrated in Pl. xi (rather low thicket) and Pl. xvii, fig. 2 (coppice). Largely on account of this predilection, partly no doubt on account of the greater scarcity of *brevipalpis* and absence of *morsitans*, *pallidipes* west of the Sitatongas appeared to be specially associated with the Puizisi-Mtshanedzi area, which carries a very great deal of wooding of these types. The coppice or fern-entwined

bush might be moderately open (as it was in Makwiana's Makubvu through the trampling of elephants and buffalos). Very frequent—almost constant—constituents of it were the small trees or large shrubs, *Brachylaena rhodesiana* (ipahla), *Markhamia lanata* (mubfeya) and *Vernonia podocoma* (mudambasese), the latter being replaced near the Sitatongas and across them by another woody *Vernonia*. *Bersama niassae* (muyahawa), *Vitex eylesii* (mukubvu) and *Conopharyngia elegans* were not infrequent, but a great mixture of other species, both of the savannah forest and the primary forest outskirts, were commonly present, and where the tree element overtopped the lower layer the wooding became fit for *brevipalpis*.

Generally speaking, *brevipalpis* needs coppice with overwood, while *pallidipes* prefers coppice without it, but in the right types such as rather poor *Brachystegia* —it can apparently dispense with yet lower growth. Clearing experiment No. 1 (below, p. 373) is of possible interest in this connection. Here *pallidipes* attacked the cattle somewhat freely in tall primary wooding in which the undergrowth had been cleared, though before the clearing only *brevipalpis* had been present; but it may have come direct to the cattle from the wooding (Pl. xvii, fig. 2) outside. It is curious that in all my special trials on the Buzi for *brevipalpis* in wooding of the types shown in Pl. xiii, fig. 1, I never took *pallidipes* either, though I did take it here in places with low growth. It may possibly best be described as a "low-wooding fly," the low wooding varying from mere coppice and bush savannah to poor *Brachystegia*, etc., though better wooding is to some considerable extent utilised.

All vleis that I came across west of the Sitatongas were searched for male clusters of this fly and the neighbouring—and other—wooding for breeding places, but unsuccessfully. Though stated to be abundant at times in the rains it is generally by far the scarcer of the two flies where it occurs with *brevipalpis*. The latter often appears to be scarcer through its reluctance to show itself to man. A point to be referred to also is the fact that *pallidipes* did not occur in all suitable wooding. Much would be passed through without encountering more than a stray fly, if any; then suddenly a simultaneous attack by three, four, half a dozen or more might take place, as already described. Water (streams or vleis) was usually present not far away, but this part of the country generally is well watered, and similar water in similar woods more often failed to produce *pallidipes*. A small dry season population in a large area, and gregarious habits, probably sums the matter up west of the hills, but a study of my notes shows also that even stray *pallidipes* were relatively seldom taken anywhere at any great distance from vleis, glades or streams.

Of *Glossina austeni* I have in my possession a male fly and about sixty puparia all taken in two localities on the Mtshanedzi, near its junction with the Buzi. Fifty-four of the puparia, empty and (judging by their muddiness) dating from the late rains, were taken in the (roughly) primary-type forest that lines the Rupisi thermal stream, from under logs. The Rupisi at this point, immediately above its junction with the Mtshanedzi, was still hot enough to give me a pleasant warm bath, and its temperature doubtless influences that of the fringing forest. The latter is of appreciable width, and is here dominated by *Khaya nyasica* and such trees as *Trichilia*. It is, to be exact, secondary forest under invasion and still contains fine tamarinds (*T. indicus*), *Kigelia pinnata* and other secondary constituents,

but the primary and primary-like elements—particularly *Khaya nyasica*, but also *Trichilia* sp., *Lecaniodiscus fraxinifolia*, musando (a splendid leguminous tree unidentified, sometimes erroneously called mukarati), *Oxyanthus gerrardi*, etc.—now so dominate as approximately to reproduce the conditions illustrated in Plate ix. The woody undergrowth is not quite dense, and there is a leaf carpet, not a live one. Great blocks of a crystalline quartzite appear above the surface, and the soil, evidently derived from this rock, is red and finely sandy but compact. Many lianas are present, and it was under an inter-coiled mass of these that the main batch of puparia (30) was found.

Shortly before reaching the Rupisi I had passed the ruined homestead of the late Mr. W. H. C. Coward, formerly a hermit in these wilds. His head-boy, aptly named Long One, had given me much information with regard to the tsetses hereabouts and had accompanied me on to the Rupisi to show me, he said, a forest in which small tsetses, in company with large, were extraordinarily abundant and troublesome in the rains. It proved to be the fringing forest I have described. The small flies, he said, would follow one out of the forest, the big ones (doubtless *brevipalpis*) often turned back on reaching its edge after humming and settling about one in the forest. He described the attacks of the small flies as surreptitious.

From four to four and a half miles on, near an outcrop of rock that perhaps represented the extreme southern end of the Sitatongas, and already beside the Buzi below the junction of the Mtshanedzi, we came on a great up-rooted tree $3\frac{1}{2}$ feet thick, lying head downwards in a donga, and beside it the rootlings of pigs. Under it at a point at which it was seven inches from the ground, were found 9 empty puparia of *Glossina austeni*, in sandy soil. The conditions were sandy, though somewhat less so than on the Rupisi.

The general country between and near these spots was open, and the grass was more or less short with stretches of long grass. The chief savannah tree north of the Rupisi was perhaps *Terminalia sericea*; a *Pterocarpus* (near *angolensis*) also occurred and in places much thicket of *Bauhinia galpini* and *petersiana*. Afterwards *Bauhinia reticulata* came into evidence and more and more, the upoza (*Combretum* sp.), together with a general approximation to the conditions of the basalt suitable only for *morsitans* and *pallidipes*. Along the rivers the dense forest wooding in many places prevailed.

There is much game in this corner of the country (Gowana's). Buffalo, sable antelope, eland, Lichtenstein hartebeest and roan antelope are all present, also a few wart-hogs, an alleged abundance of pigs and baboons, monkeys (*C. pygerythrus* in the tree-savannah, *C. albogularis* in the thicker forest, as also much blue duiker), waterbuck, reedbuck, and plenty of bushbuck and cane-rats. Vleis (not seen by myself) are stated to be present, but not many.

The one fly (*austeni*) taken by us bit the native who was giving my breeding flies a feed from a goat just outside the edge of the heavy Rupisi wooding, and possibly thereby exhibited a preference for man as against goat.

Moisture and Rainfall.

Morning mists, very wetting to the leaf, occur not infrequently in the dry season between the Sitatongas and the British border, especially in the great river valleys.

In the bare glades and vleis of the *Brachystegia* bush of the granite-gneiss not only is there a continuous evaporation in the dry season from a considerable underground water supply, but the nightly cooling is such as to produce regular dews—as it does also, to a lesser extent, even in the drier open spaces in the woodland. If, then, the sucking of moisture from wetted grasses which appeared to take place in my tubes should also take place in nature, we should have a probable partial explanation of the attachment of *morsitans* (and in the same area *pallidipes*) to the vicinity of vleis and glades. In one instance a large fly-cluster was observed to travel quite a mile and a half in the course of a few days entirely along a connected or but slightly disconnected series of small glades in the bush.

In view of such evidence as is alreadyavailable (page 341) I rather strongly suspect that tsetses will be found to partake fairly frequently of water in one form or another, especially the species that do not rely on heavy shade, in which dew is also less. It is conceivable that the slight occasional snacks of blood taken by male tsetses when travelling are as often for moisture as for food.

At any rate the point with regard to water-drinking deserves investigation, seeing that the practical application of a discovery that tsetses regularly drink dew might lie in the possibility of poisoning at least the male flies at their dry season concentrations—as one of several contributory measures for the flies' destruction there.

Rainfall probably affects the fly here mainly in so far as it influences the nature of the bush, the period of leaf-fall and (for *morsitans* and *pallidipes*) the permanence of the moisture in the vleis, etc. I found *brevipalpis* and *pallidipes* both east and west of the Sitatongas and on the British border, though we have here, undoubtedly three different rainfalls. The confinement of *morsitans* to the smaller rainfall area east of the Sitatongas will be referred to below.

Up to 10th September (the end of the investigation), no matter how apparently suitable the wooding might be, I found no *brevipalpis* and only once a *pallidipes* in the immediate neighbourhood of river banks west of the Sitatongas ; I refer to such rivers as the Buzi, not mere overshaded streams like the Inyamarimu. Yet on getting a bit back from the river, fly (mainly *brevipalpis*) was found generally and in quantity and thence up the hills to the limit of the suitable bush. There seemed to be a definite avoidance of the big rivers—possibly a matter of the greater winter cold in their vicinity. With *austeni* it may be different.

Elevation.

The effect of elevation was tested for *brevipalpis* and *morsitans*. Forty pupae of the latter fly were sent, twenty each, to two friends living in the mountains at about 3,400 (G. D. Otterson) and 3,900 feet (J. W. Scott), respectively. Each batch was placed in a little sand and leaf-mould (taken from the places I found them in) in a wide-mouthed bottle covered with gauze. Each bottle was placed under a slightly raised log in semi-shade, this reproducing the natural conditions, and the temperature was taken daily. I kept a control set in a similar bottle in the lowlands.

The mountain sets were sent up late in June and more than a month of very cold weather supervened, including, it is stated, the coldest that we have had for some years. Without going into the details here it may be said that the tsetses of the low veld control showed no advantage over those of the highland experiments. The percentage of failures was approximately the same, and the emergences both of the tsetses and of their parasites took place as well in the mountains as below. This is perhaps not surprising when one considers the elevation at which *morsitans* occurs in Mashonaland.

I could only test *brevipalpis* observationally. On 27th–28th August, the colder weather being just over, I climbed the hills overlooking the Inyamadzi towards Spungabera up which the continuous *Brachystegia* bush extends to a considerable elevation, and I found *brevipalpis* present on the highest points at which bush conditions (except in certain inaccessible kloofs) were suitable for that fly—that is, so far as I could judge from the known elevation of the valley bottom, at an altitude of about 3,000 feet. It was steep and rugged here, but tracks of pigs and baboons were present. I understand that Jack took a *pallidipes* in August 1917, almost at the level of Spungabera, but the place (pointed out to me by Dr. Lawrence) suggests that it was a "carried" fly stranded there. In these observations on *brevipalpis* there was no break in the fly's continuity, and from one to several flies attacked from the thickets right along from the Buzi to these high points near the border and back.

I have already referred to my observation at Makwiana's escarpment (fly at the bottom but none at the top), but this was simply a matter of shade versus none. The cattle sustained early morning attacks (before sunrise) from both *brevipalpis* and *pallidipes* with the thermometer at 47° F. and under. *G. austeni* was taken at an elevation of (probably) six or seven hundred feet.

Shadeless Barriers.

The isolation of patches of woodland suitable for the tsetse seemed of some importance in relation to *G. brevipalpis* in *Brachystegia* bush on the extreme edge of its area and where the intervening bush was already stripped of shade.

Ascending at the end of August the slopes from the upper Buzi or Inyamadzi, or merely passing along near the bottom of the valley of the latter river with no alteration in elevation, one came out into completely leafless bush (*Pterocarpus*) or open grass, and I failed to find any fly at all in kloof strips or *Brachystegia* groves isolated in or by these shadeless stretches, although they were certainly too narrow on the Inyamadzi to act as a definite barrier to either sex.

The obvious explanation seemed to lie in the refusal of *brevipalpis* to venture outside continuous shady bush except under certain conditions of light not common in the dry season, and then probably only if it can find a non-human carrier to take it. Unfortunately for this view and the practical suggestion arising from it, throughout the parts traversed of the low-lying crescent (Umzila's guard-area) that descends the Mtshanedzi and swings back up the Puizisi, the smallest patches of dense forest with shrub growth below were very apt to shelter *brevipalpis*, few or many. The fact that the intervening bush was not yet leafless (in August) doubtless helped, and in places (as on the road east of the Chikambwe) this bush

itself carried some *brevipalpis*; but in Mtobe's area the intervening spaces were largely mere grass or bare *Pterocarpus* as on the Inyamadzi, yet the scattered darker thickets carried unusual numbers of the big fly. The clue is doubtless given in part by the fact that an actual detached primary-forest clump, diminutive enough, near the Inyamadzi-Chiredza junction did produce a few *brevipalpis* and that the *brevipalpis*-producing clumps in Mtobe's, etc., were of the shadier dense secondary or more or less primary types. The temperature conditions in continuous bush are more equable than in isolated patches, and the conditions for the existence of the fly may have been lost in such *Brachystegia* patches, though retained by quite diminutive clumps of the denser types. The *Brachystegia* bush on the Inyamadzi is rather poorer in any case in thickets and in fly than that across the Buzi, and it is right on the edge of the fly area with no passage to points beyond. Even if the explanation suggested is the correct one—and it must be noted that the observations it is based on were scanty—splitting up the shelter, as a substitute for complete clearing, on the margin of such an area would (by itself) exclude the fly only during a small portion of the year.

Interesting also was the fact that kloofs ascending towards Spungabera from the infested *Brachystegia* wooding on the Buzi showed no *brevipalpis* appreciably above the general margin of that wooding, though much of the wooding in the kloofs was apparently still suitable for it, and I had taken this fly up to a greater elevation near the Inyamadzi. The explanation that this is due to the necessity for a compact breeding population (possibly in part applicable to the occurrence of *morsitans* centres in some vleis but not others) seems discounted by what I have just related of Mtobe's country; but this principle would doubtless show best on the margin of a fly area and if there were no passage of game to carry the flies to points outside. It was perhaps significant here that below the Spungabera forest a line of precipices divided the general fly-bush below from a wood of *Brachystegia* above in which there was much leaf and undergrowth but no fly, and that further along northwards the limit of the fly at that moment was not quite that of the *Uapaca-Brachystegia* bush itself but a little inside it at the foot of a precipitous slope up which the Gogoyo-Spungabera path goes, and on which the above bush terminates. The absence of fly from the *Brachystegia* bush above the precipice might be explained in any case on the lines that I have suggested for the isolated patches on the Inyamadzi, but the precipice very definitely and the steep slopes to some extent do seem to mark the limit here of the freer wandering of the pigs and other large mammals; though pigs and baboons are said to come up in numbers in October and November to eat the ripening manzhanzhe (*Uapaca kirkiana*) fruits, and buffalos come up in the rains (especially from south and north of the more precipitous barrier) and, as the indirect evidence shows, bring up tsetses. I have been interested to hear from Mr. A. J. Orner, who has been along the path there recently in the rains, that even at that season, though he saw *brevipalpis* all the way from the Umtwadza to the foot of the steep ascent (mostly male queues in the path after sunset), after commencing to climb he saw not one more. In the rainy season there is much leafy wooding with thickets above the *Brachystegia* also, thus adding to the interest of an observation that is, however, incomplete through the absence of cattle bait to draw the fly out.

Grass Fires, Grass Growth and Soil.

The fires scorch the leaves and undoubtedly drive out the tsetses for the time being from the area burned, but on the granite-gneiss, on 27th July, I found *morsitans* had returned to a patch of ground that had been fired on 5th July. The grass was already 6–8 inches high even in the drier vleis and the trees on their edges, stripped by the fire, were already coming back into leaf.

Of *brevipalpis* it must be said that of the two types of forest that it inhabits, one (primary forest and its extensions) never burns save along its edges, except in special circumstances which I have referred to already.

With one possible exception, I should say that the tsetse pupa has no necessities such as are not found incidentally in the environment necessary to the adult fly. The nature of the surface soil is, I judge, a matter of nearly complete indifference as a direct factor, for some slight accumulation of detritus is almost always present in such spots as receive the larvae, and I have found puparia on all soils. As an indirect factor it may be far more important, for it is quite certain that at most only an occasional pupa could survive the extraordinarily fierce fires of the heavily grassed dolerite outside the denser woods, when they do not take place too early.

Food Supply.

I have already referred to the rôle of the big game in annually re-distributing the fly. I found no country in which largish mammals (pigs, bluebucks, etc.) were entirely absent, so that I am unable to say from my own observation that the fly can or cannot exist without them. That man must contribute much to the seasonal dispersals of *G. morsitans* I had abundant evidence, and I had plenty of evidence also that it does not avoid native kraals if trees are present.

Two apparent Fly-barriers in Mossurise.

(1). *The Sitatonga Hills.* These (except possibly at their extreme southern end) form the eastern boundary of the *morsitans* area. That this boundary is permanent there can be no doubt. It was the boundary when I visited the area in 1900 and it still is to-day. I failed to find the fly or its pupa west of it, and no *morsitans* has been amongst the numerous flies (*brevipalpis* and *pallidipes*) that have been collected for me during many months by Dr. Lawrence. Mr. Jack, who passed from the Gogoyo (Dysart) station to Mtobe's, under the Sitatongas, in 1917, also took no *morsitans*.

The Sitatonga Hills are a lofty and uninterrupted "knife-edge" passing right from the Lusitu to the Buzi. There is relatively little back and forth movement of game except at the southern end (where the buffalos have a passage), and it might appear therefore that the ridge acts as a barrier, either direct or (through the game) indirect. On the other hand, at Umtomana's pass and about it the hills are very passable by game and have probably constantly been crossed by them formerly and are crossed to some extent now, and a main native path goes through here. My temperature experiment (above) suggests that the mere height of the hills will not constitute a direct barrier; and (a conclusive argument) the ridge evidently acts in no way as a barrier to the distribution of *pallidipes* and *brevipalpis*, which occur freely on both sides of it; why then should it to *morsitans*?

We must look for an explanation to a difference in the conditions. They are as follows :—

G. morsitans present.	*G. morsitans* absent.
1. Smaller rainfall.	1. Larger rainfall.
2. Surface soil loose coarse sand on gneiss, compact on basalt.	2. Soils compact, much humus in denser wooding.
3. On gneiss impervious kaolin substratum bottoming numerous vleis, the latter fringed merely with the *Brachystegia* of the general wooding.	3. Vleis fewer, mostly small and more often with long grass ; permanent streams numerous, largely fringed with big trees.
4. Poor clean-stemmed savannah forest (*Brachystegia*) on gneiss ; scattered bush savannah on basalt ; each type continuous over a great area.	4. *Brachystegia* savannah forest on sedimentary rock far finer and with, in general, much more undergrowth ; on dolerite in widely scattered groves. Here the main wooding is (*a*) dense secondary types, also primary ; (*b*) highly deciduous tree savannah.
5. Grass mostly short, fires not severe.	5. Grass of tree savannah immense, fires fierce if late, milder in the denser wooding.
6. Much big game.	6. Except in "Oblong" less big game, but many pigs, etc.

2 and 6 may be dismissed. I found successfully emerged *morsitans* puparia on the compactest of soil on the basalt and the other two tsetses seem able to subsist here in numbers in the absence of much "big" game, as *morsitans* also did after the rinderpest.

4 and 5. If (as is likely) it should be that only the tree savannah of the dolerite is really, as a whole, suited to *morsitans*, then its high deciduousness, with its fierce fires, should suffice to exclude this fly except as a possible summer visitor carried in on game or man. The scattered *Brachystegia* groves of the dolerite are utilised by *pallidipes*, and it is likely enough that it retires to these when the dense secondary wooding loses leaf towards the end of the dry season ; but to *morsitans*, unable to use the bulk of the bush, these *Brachystegia* groves would stand in the same relation as the outliers of the *Brachystegia* of the higher Buzi in which I failed to find *brevipalpis* do to the latter—only they are much farther away from the main block and separated from it by a high hill range and the two narrow and broken strips of dense, unsuitable wooding that fringe its eastern and western foot. To this extent the Sitatongas are a barrier, and doubtless also if they were more freely crossed by game *morsitans* would appear more frequently on their west side in summer. The apparent absence of *morsitans* from the generality of the continuous *Brachystegia* wooding of the "Oblong" (neither Dr. Lawrence nor I have obtained any thence) seems to suggest that the difference in shade and undergrowth between this type of woodland and the poorer type on the gneiss is sufficient to exclude this fly.

To be able to assess the influence of the rainfall here one would require to have figures from many *morsitans* areas. It certainly seemed to me that *morsitans*, on the gneiss, was very dependent on vleis of a particular type for its dry-season breeding. Vleis quite of this type are rare, if not absent, on the west side of the hills, but it is again difficult, without an acquaintance with other *morsitans* areas, to know if these vleis do really represent a vital condition. It may be this factor, rather than that of the wooding, which causes the demarcation, and at present that is rather strongly my opinion.

In general it does not seem likely that the country west of the Sitatongas, at any rate north of a line drawn through the middle of the "Oblong" and parallel to its greatest length, is in any danger of being invaded by *morsitans*. Occasional flies might be carried over the hills by Kafirs or game, and the latter would probably happen more frequently were the kraals on the eastern foot of the hills to be removed.

(2). *The mountains of and near the British border.* These constitute the western and northern boundaries of the *pallidipes-brevipalpis* areas, and for a clear idea of them the map should be consulted. Generally speaking they form more or less of an escarpment, abutting on to the fly country on these two sides.

The great rise in elevation seems at first sight an adequate reason for the existence of the fly boundary, which, it should be repeated, appears always to have stood approximately where it is now, except when pushed east by Kafir settlement. No doubt the British hills north of the Lusitu (6,000 feet) and the Chimanimani (much higher) would act in this way as a direct barrier, but it is more than doubtful if, from the Lusitu southwards, the elevation (with maximum heights of a little over 4,000 feet) is sufficient to act as a direct deterrent to the fly. On the contrary, a glance at the map shows clearly that it is the great continuous pieces of wooding of the right types that really delimit the fly. Where these ascend mountains, the fly ascends equally; where they stop short in low-lying valleys (Inyamadzi, Chiredza, Buzi, Lusitu), the fly stops short too. It happens that these great pieces of wooding cross the British border for a short distance only where they touch it. With regard to the wet season fly, which is capable of being established temporarily by game in occasional pieces of wooding such as exist abundantly enough even on the British side of the border, another factor must be mentioned—the white settlers on the border and such native kraals as are present. Our experience shows that these do act quite considerably as a deterrent to the passage of the wandering big game, and that where a white man shoots much or native kraals are numerous a useful "guard" against the fly is thereby established.

In general, however, the summing-up of old Inyabangwa, who long ago herded cattle for the Zulus on the edge of the escarpment, fits the case. "They are barred, sir," he exclaimed, "barred (zi-vimbekile, 'nkosi, zi-vimbekile). They fear the open country (izimbaya) of the mountains and they fear its cold winds."

XII.—Notes on Habits.

Waiting Habits.

I have referred to the tick-like habits of tsetse. I came across no evidence that the flies wander to any extent in search of their prey, though a good deal of local activity is shown by male *brevipalpis* after sunset, and females then attack from a greater distance. That some of the stray flies found in the country generally are carried, I had evidence in the sudden appearance of my marked flies in native villages immediately after parties of reed-cutters had passed through them from my vleis.

G. brevipalpis may be found in the day-time scattered through all the little thickets in the bush it frequents, two or three or more to each. Just at sunset the males emerge from the thickets in the neighbourhood of game and other paths and (where plentiful) distribute themselves at short intervals along them, sometimes

for a considerable distance. As one walks each male moves on in front of one for at most a few feet, evidently scanning the walker for any females that may be with him, then falls behind. At one time when a domestic matter called me home from the Buzi, my police boy, left in charge of the work, captured no less than 88 of these flies, every one a male, on three successive evenings without the aid of cattle along the same stretch of path. The path here passed alternately through bush suitable to *brevipalpis* and more open spaces. On emerging into the latter one ceased to see flies; on entering bush further on one found them in the path. This was a little curious seeing that it was after sunset and rather suggested that they had not come far.

The males of *G. morsitans*, though occasionally seen like this on game paths, were found mostly crowded together in the short grass beside the path—some of them on the path—and were also (as events each time fully proved) watching for females or carriers to take them to the females. *G. morsitans* usually waited in a crowd, *brevipalpis* always in a queue.

Travelling Habits.

G. morsitans utilises man as a carrier far more freely than the big fly does, and as these followers occasionally bite, they would give an unobservant person the impression of persistent attacks by large numbers of tsetse. It is, actually, nothing of the kind, but, in essence, a ride in search of females. This is most clearly seen when the flies are few and on the back of the person in front. I have watched male flies, each with its station on a particular spot on the back of my guide, travel thus for miles. They would keep taking short flights off all the time and at once return to their previous station. Whenever I saw the object of the flight it was another fly, and the fact that the flights were in search of females was sometimes proved by a witnessed pairing.

That these rides on man would be useful even where the females were not feeding on man was supported by the many instances I saw in which flies came out to us and turned back, evidentally rejecting us. (These observations were on *brevipalpis*.)

Where I have walked slowly the tsetses (*morsitans*) have some times contented themselves with moving along in the grass beside me. More often they—or some of them—attached themselves to me when I was moving and each time I stopped dropped to the grass again till a movement showed it was time to start. There can be little doubt that when on the grass they watched for females coming to me, for such females were at once assailed. The low position adopted by the tsetses during these waits was doubtless of considerable use in showing them the females against the sky, and in helping them to detect and keep in touch with moving objects generally. Flies that had flown off a man's back to accost another fly always returned flying very low and rose to his back. The principle is that of the nightjar or of the man who stoops to watch crepuscular insects or birds. These clusters of male flies varied greatly from day to day in numbers and position, reductions definitely resulting both from the depredations of birds and from the flies attaching themselves to passers by. With buffalos present the clusters practically became non-existent. They always tended to form again later, but were not always composed of the same individuals, for experiments with marked

flies showed that these reappeared in other clusters than those in which they were marked; and the immense preponderance of unmarked flies in clusters that I had taken pains to mark pretty fully suggested that they were being kept up not merely by arrivals brought from elsewhere and from males that had probably been resting, but by new emergences in the neighbourhood, such as were actually noted in searching for pupae. In each case active breeding centres and clusters were never found otherwise than in more or less close contiguity.

There was a certain amount of day-to-day movement on the part of some of these clusters as a whole, but it was gradual. The one nearest my Kanyezi camp was very stationary, its movements being mere fluctuations, and after a three weeks absence I was able to find both this and the other clusters almost where I had left them and to retake in them a few of my marked flies.

Males of *brevipalpis* waiting on game paths were frequently tempted to attach themselves to the cattle and would then often ride for quite a distance. Sometimes they fell behind them, as they fell behind ourselves, probably because they found that they carried no females.

I measured one of these rides by five male *brevipalpis* in dull weather, first marking each of them with a dab of white paint. The flies had come to us just before and were following, not feeding. The greatest distance travelled was $5\frac{1}{4}$ miles by the one fly that stayed to the end. All five flies were still present at 4 miles and 700 yards. Every kind of country was traversed, *brevipalpis* bush, simple coppice and open grass.

The flies deserted us on our getting back into their native bush. Elsewhere where *brevipalpis* had followed us into the open in the daytime it waited before leaving us until it had reached suitable bush, and an individual that once followed far to a camp in the open stayed about for hours (in the evening) before disappearing. All this was interesting in relation to the explanation of outbreaks of nagana in which it appeared that the fly had crossed much open country to bush—patches in the grazing grounds or near a kraal.

I tested similarly the distance to which *morsitans* will follow man. Twice I obtained rather more than six miles, and many times various less, but still long, distances. On one occasion a journey of over six miles was done in three instalments by a marked fly on three successive days. The riders were almost always interrupted by reaching, sooner or later, another clump of male flies into which the male riders then disappeared. Otherwise, and with more time to experiment, the rides might well have been much longer, and Bevan (I think) has recorded an observation of Meikle's in which tsetses were still on his cattle 25 miles outside the fly-belt. A common position was on the load of a native carrier.

In the foregoing experiments and observations the flies that really travelled were invariably the males (marked with a different colour), and it was these only in the case of *morsitans* and *pallidipes* that had up to the time of my departure put in an appearance at villages a few miles outside the breeding centre in which they were both captured and released. Hungry flies, including, so far as I saw, *all* females, came to feed, not follow, and the longest distance travelled in an experiment in which I released a considerable number of hungry marked *brevipalpis*

and a few *pallidipes* behind the cattle was 820 paces quickly covered. The other flies had already dropped off replete before that, in spite of the kicking and running on the part of the cattle.

The question of the females travelling, even on animals, is an important one in relation to the question of possible control by barrier clearings, and is worthy of more extended special experimentation if long distances have not yet been recorded for it.* In Simpson's experiments with marked male and female flies on the Yapi-Tamale road, in the Gold Coast, only one recaptured fly was found more than two miles from the point of release, and all were retaken near the road, on which there was considerable traffic. Unluckily in stating the result he does not separate the sexes or state the time that elapsed between release and recapture. A female could readily cover two miles on successive journeys on man and animals, especially if much disturbed in her feeding. In Lamborn's experiments only males were retaken.

It is obvious that a fly-belt can only extend definitely, whether its annual extension into highly deciduous wooding is concerned, or a permanent extension into country previously uninvaded, at the same rate as the females. This, if I am right in my present belief that the females do not travel appreciably on their own initiative or to any distance on animals, suggests that the extension will be slow and compact and indicates a possible explanation for the alleged fact that the cause for the division between fly and non-fly country is sometimes not to be found in any difference in the conditions of wooding.

Living in a district that is right up against the fly I have come across no evidence at all that either sex travels appreciably on its own initiative. There is on the other hand, a very great deal of evidence to connect our local outbreaks of nagana with the movements of big game. I do not think that a fly area will extend seriously in the absence of game.

Migration and Homing.

The fact that the flies are found still in their centres in great numbers when food is scarce, and even under such conditions of hunger as have been described by Maugham and as, it is just possible, I saw myself in 1900,† tells against the theory of unassisted outward migration, though the predilection of the "following" males for joining other fly-clusters they may meet on the road amounts to unassisted migration of a kind. It is also quite certain that in South Melsetter, with the fly right on our border for 20 years past and numerous herds of cattle grazing in and near *Brachystegia* bush at relatively low elevations, we should have met with much indirect evidence of migration were such to take place.

* Against the obvious suggestion that the barrier could be narrow must be placed the possibility, to be referred to below, that females as well as males do not dismount readily in uncongenial country once they have allowed themselves to be carried well into it. This point needs testing also.

† I see from my journal of that time that the tsetses "swarmed and were very irritating." Game was not quite absent, but, with the exception of duikers, was very scarce, having left this unburned country for the green patches on the basalt that had been burnt earlier.

That homing occurs, within limits, is to me certain. On 29th June as soon as I entered a male crowd the flies as usual attached themselves to me and kept pace with me, buzzing about my feet. On my leaving the vlei and entering the *Brachystegia* their numbers fell off rapidly, only a few following me 50 yards in. I stood still finally when all had left, and after a few minutes returned to the cluster to see if I should pick up the flies along the path, where they had left me. I saw not one fly till I had got to the cluster, in which they seemed as numerous as before. It seemed probable that on leaving me they had flown straight back to the cluster. Natives arriving with loads shortly afterwards passed through the cluster and a number of the flies accompanied them right through to my camp—a further 150 yards—possibly a matter of preference. They stayed for a short time, occasionally biting, then all disappeared.

Similarly whenever we emerged from a cluster, followers would just at first often be numerous, but for the most part would fall off within a very few hundred yards, and on the analogy of the above observation and from certain takings of marked flies, it seemed likely that these short-distance flies had flown back. The numbers of the remainder lessened rapidly with the distance travelled and relatively few followed for some miles. Would these long-distance flies also find their way back unaided? Would they necessarily proceed further than the first useful vlei? And if deposited in congenial surroundings, would they necessarily return at all? The experiments known to me on the subject of long-distance homing do not (as described) seem to settle conclusively the question as to whether it was unaided. Simpson's were on highways of traffic. His recaptures were many and confined to the vicinity of these highways—road and river. Lamborn's recaptures were few and his general distances longer. From my cattle experience I judge it to be likely that fly will go farther on game than on man. They also, in my observations, tended to travel farther through unattractive country, once there, than through country offering temptations to dismount. This suggests further the need for a closer description of the country searched on the wrong side of the point of release. The question is of some possible practical importance, and it was, therefore, a matter of regret to me that lack of time, with the fact that on first leaving the Kanyezi centre I did not know if I could return to it, prevented me from carrying out long-distance experiments of my own.

My incidental evidence suggested that homing does not always take place at once. The fly that I have described as travelling six miles in three stages reattached itself each time at the spot at which it had left one or other of us the day before, and other isolated instances of the same thing occurred. Of my marked flies that were carried to native villages a few miles off two were reported as staying about for from two to four days before disappearing—when they may merely have moved farther on on natives or have been killed. Further evidence was obtained in investigating a severe and sudden outbreak of nagana in a large herd in British territory, very many miles from fly (permanent or otherwise), which appears to have been caused by male tsetses carried by game. It had taken place at the commencement of the dry season. The native in charge and the herd boy, interviewed separately, each picked out tsetses (from amongst my specimens) as having been on the cattle before and during the outbreak and stated that they had appeared suddenly and stayed three weeks or rather more. They disappeared "when the leaves fell"—a spontaneous

piece of evidence which, coming from high-veld kaffirs previously unacquainted with tsetse, seemed rather convincing. Whether they then "homed" or died it is impossible to say. Old natives who herded cattle in the earlier days of Umzila's experiment had previously given me similar instances of long stays by the fly. Of course there was an attraction, but the seasonal spread of the fly into other deciduous areas (*v.* Sections ix and xvii) will itself, if fully confirmed, constitute strong evidence against the universality of homing, as the well known recent spread of many fly areas already does against its completeness.

Hours of Activity.

G. brevipalpis, as I found, attacks in the shade of the bush at any hour, but does not fly appreciably outside its own thicket to do so except in the early morning, after sunset and on dull or rainy days. Having attacked, even in sunny weather, it completes its object of feeding or riding, unless its victim emerges into the open. In this event it usually leaves. In a special experiment that I carried out with the aid of a lantern occasionally lit and turned on I found that both this fly and *pallidipes* attacked right up to dark. Then every fly suddenly disappeared. On moonlight nights they continue their attacks, and all three flies come to light, including fire-light, and, once there, bite freely. *G. morsitans* I found, as have other observers, to be most active in the rather warmer hours and least on cold or dewy mornings, but it too attacked up to dark. It is probably dependent on shade to retire to occasionally when blood and water are not available, for I captured several male flies that had been resting under logs in the wooding adjoining vlei edges frequented by male clusters. The frayed wings of some showed that they had not just emerged.

The Bite, and the Attack; Methods of Marking.

Nothing struck me more than the frequency with which a fly would steal a feed from the back or (especially) leg of a kafir walking in front of me and fly off replete before the man noticed it. Very frequently the first intimation of the fly's presence comes with the final withdrawal of the proboscis; sometimes even that is not noticed. At other times a bite is noticed instantly and felt acutely. The natives who converse on the phenomenon hold that a bite over a bone hurts and in a fleshy part does not, but it is obviously a matter of local presence or absence of the specific sensory nerve-terminations. I have myself had both painful and painless bites quite close together on my forearm.

The practical bearing of the fact is in relation to the criticism (based on the success of observers' pet animals) that flies will not make good their feeds on baboons, etc., and that such animals need not therefore be seriously considered in relation to the effect of game destruction. A second fact to be remembered here is that captive animals have abundant leisure for fly-catching. A wild baboon is often absorbed in raiding, hastily cramming his pouches, quarrelling, keeping up with the troop, or participating in shouting contests. Especially where tsetses are present all the time, he can hardly attend to them except incidentally. The black man in these circumstances brushes the fly he notices away—commonly, if walking, by a wrist movement that brings the butt of his assegai sharply to the point on his back that was bitten—and the fly at once returns; he makes an effort to capture it chiefly when

he is idle. When watching tsetses in my net experiments I relatively seldom noticed the approach of any that attacked, though their attentions were sufficiently annoying to make me wish to do so. A male in search of females approaches boldly enough and is not silent, but the attack of flies intent only on feeding is often remarkably surreptitious.

I was never bitten through my clothing by *G. morsitans*, but very frequently indeed by hungry *G. brevipalpis*, both through thin shirt and vest and strong khaki trousers, though I occasionally watched flies probe for a time as though unable to penetrate. The scrotum (when one squatted) was almost always the point of attack, and this accorded well with this fly's habit in relation to cattle. It always attached itself to their bellies, more or less in the median line, or between the fore or hind pair of limbs. The kicking of its belly by a beast in *brevipalpis* country almost invariably indicates that it has been attacked by that fly. The position chosen has probably as much to do with considerations of shade as with the thinness there of the skin, and some very hungry *brevipalpis* released by me behind running cattle fed at the first points reached, including the flanks, whence one was seen to be licked off—suggesting a further reason for the selection of the belly by a fly that is less active in avoiding such reprisals than is *G. morsitans*. The smaller tsetses attacked more on the flanks and forequarters and lower down.

I carried out an experiment in trapping tsetse by fastening skins smeared with bird-lime on the goats and under the animals' bellies. The fly-catching properties of the lime, made from *Loranthus* berries, were excellent, but it speedily became so masked with leaves and grass blades as to be useless.

I have referred already to the low poise and sidelong, running, almost *Olfersia*-like movements of the fly in evading reprisals. This is well seen when the natives try to catch it, as they frequently do, by "treading on its toes" with the edge of an assegai or knife. Occasionally a leg is damaged in the process and this, with the attacks of birds, makes unreliable the method of marking by snipping off a portion of a leg that was adopted at first. I later used paint from water-colour tubes, placing with a small brush a dab of white or colour on the back of the thorax and varying its position and size. This proved excellent. It enabled me in some cases to recognise individuals again and again, and the conspicuousness of the mark brought me reports from the natives as to the spots at which such flies reappeared. It doubtless also carried with it the disadvantage of laying the flies open to detection by birds—a consideration that is of less importance in relation to the males, which, in any case, trust more to activity and less to concealment than the other sex.

XIII.—Proportion of the Sexes.

The following statements represent the result of day-to-day observation and analysis in the field—the only reliable method.

(1). Wherever we had to deal with male crowds or queues awaiting females or, in the case of *brevipalpis*, the bush immediately bordering on the path on which the male flies would line up at sunset, we took, as might be expected, practically nothing but males.

(2). Elsewhere, using cattle bait, we found usually either an approximate equality of the sexes or a preponderance of females.

(3). Many more females proportionally came to cattle than to man and goats.

The cattle were with me only during my last four days in the *morsitans* area (three at Kanyezi centre), but the proportion of females rose abruptly on their arrival. It amounted now to from 35 to 40 per cent. in spite of the fact that the cattle were used very largely at a strong male cluster in order to obtain the material for certain experiments. Previously 7 per cent. had constituted a good day, the only day on which I had surpassed this figure being one (1st July) on which the already weakened male cluster at and near which we were catching had temporarily been obliterated by the passing through it of a buffalo. The percentage of females for that day only was 30, and it was also the one day on my first visit on which *pallidipes* (taken one here, one there) predominated, but the total was in any case diminutive, not exceeding my daily catch minus *morsitans* males.

Bagshawe's result (more male *palpalis* where crocodiles were present, more females where not) and McConnell's (more *palpalis* females on the small tributaries —where food is doubtless scarcer—more males on the main Nile) appear to be completely explained by observation No. 3, above. Bequaert's observation (more males in uninhabited regions, where non-human food would be more abundant) would appear to be the same, had not Graham (quoted by Bagshawe) noted that, in Ashanti, *palpalis* prefers human blood to that of cattle. But both Graham and Zupitza (also quoted by Bagshawe) observed that when flies bite readily males are not in excess.

In spite of a heavy preponderance of males in my total takings—the inevitable result of following paths and of special attention to all male crowds or queues with a view to obtaining material for my marking and other experiments—I came across no evidence at all which, properly analysed on the spot, suggested an actual preponderance of the male sex. Rather the reverse ; and it was likely, both in view of the systematic attack by birds which I found taking place on a conspicuous male crowd and from a consideration of the breeding habits (which are such as to allow for much male wastage), that, at a given moment and apart even from the freer dispersal of the males, the females are more numerous than the latter, though they will show themselves in their true proportions only when hungry.

Dr. Lawrence's numerous small sendings of flies, lasting over many months, showed (in *pallidipes*) a remarkable equality of the sexes even in the individual sendings. Here we have a locality in which game generally is rather scarce and even wild pigs, it is stated, unusually so ; also no male fly crowds, in so far as I have seen or heard, but mere individual attacks by single flies on natives passing or working. In the stray individual flies of *pallidipes* and *morsitans* taken by myself over a far greater variety of country both east and west of the Sitatongas, some of it with much game, the females amount approximately to one-third, but a few stray flies taken on cattle (on 1st Aug.—females over 50 per cent.) are included here.

Attacks by several *pallidipes* together (except at the waiting male crowds of the granite-gneiss) were very different. Here the tendency to equality was great, and on at least one occasion, to judge by the captures, only females were present. But we had no such attacks except on the cattle.

The above results from *pallidipes* may usefully be contrasted with those obtained from *brevipalpis*—a fly which is very loth to feed on man; and it must be remembered again that the female sex comes primarily to feed. In Dr. Lawrence's sendings (mainly flies taken on natives) practically all the *brevipalpis* are males. Except in the pig observation (p. 337) this was my own result also, till I used cattle bait.

My results would seem to place Lloyd's suggestion outside the category of theory and further to show clearly that the apparent scarcity in the presence of game of the females of the three flies chiefly investigated is probably due to a relative dislike of man.

The fact that *morsitans* and *pallidipes* might be found about native villages where the shade was suitable, was, as I shall show, the natural result of villages being centres of arrival from the surrounding country, together with the fact that these flies do attack and (in particular) follow man. It does not invalidate their probable preference for game.

XIV.—Observations on Breeding Habits.

Glossina morsitans.

Wherever I went I searched diligently for pupae with all the natives at my disposal, including often a number of local natives incited by the offer of rewards. Special halts were made at likely or typical spots or at mere fallen logs, and the normal halts were fully utilised. My general lack of success was remarkable, and the two or three solitary, evacuated, muddy, wet season pupae found corresponded with the sparsely scattered character of the actual fly in most of the *morsitans*—*pallidipes* area. Only one small find of puparia (evacuated) was made on the basalt in spite of a week's exhaustive search in the country round my camp, both in river bush and bush savannah, by a large and quite keen gang.

At some of the better vlei-series (by no means at all) the indications were very different, and at one of these (shown on the map as Kanyezi's) I stayed at the end of June and again at the end of July, for about a week each time. Buffalos had been present here in very great numbers in the late rains, but had left two months before my first arrival. During my stay a small herd of Lichtenstein hartebeests, small droves of wart-hogs, and latterly a solitary buffalo bull were about the only large mammals present, except an occasional duiker, a leopard and three passing lions. The buffalos had left some heavily trodden-out game paths, now used mainly by ourselves and once by the solitary bull. Thorough searches for puparia were made both near the game-paths and away from them and near the vleis and away, and I took many hundreds of full and evacuated puparia in all from more than a hundred breeding places. The puparia were not, like Lloyd's, necessarily connected with the game paths, though it was not easy to get very far away from these; but the muddy ones were more or less confined to areas well grazed by the buffalos, and all were confined to the wooding in the immediate vicinity of open vleis and glades,

to the borders of which and the old game paths traversing them the male flies were obviously betaking themselves on emerging. The soil was sandy, the formation was granite-gneiss, and the wooding was the *Brachystegia*-dominated savannah forest of that formation.

The females when not feeding certainly spent their time in hiding away—from the males (as Lamborn has suggested) and, I am certain myself, more especially from birds and the sun. The indirect evidence showed clearly that it was mostly when thus hiding—in a spot which suited their own convenience but by no means necessarily that of the pupa (*cf.* also Lloyd)—that they dropped their young, sometimes (as my indirect evidence again most strongly suggested) from several feet from the ground. Most of my puparia were found under prostrate trunks and branches, raised little or much from the ground, but batches were also found in the angles of root-buttresses, under mere leaning trees, under fallen palm leaves, and below and between the outleaning dry leaf stems at the bases of palms (*Hyphaene ventricosa*), in holes in trees and in holes made by animals in banks, and where the hoof-marks of passing animals had broken the slight crust of a sandy stream-bed immediately under light overhanging grasses. I failed, in spite of much search, to find tsetse pupae in the leaf-sheaths of palms, though I took Lepidopterous and often other Dipterous pupae there. The situation was usually dry, but some of my sand-stream pupae were in a moist situation, and I took a pupa-case that had emerged successfully under a fallen *Eugenia* log in very damp ground on the edge of a vlei.

I also carried out an experiment, lasting many weeks, with the pupae taken. Some were exposed to conditions as normal as I could make them, some were in soil exposed to day-long sunlight and others were in ground kept always moist and either warm or cold. It was wonderful how well those exposed to the extremes (perhaps less extreme than the conditions used by Roubaud) emerged, but less so when one remembers the continuous state of the ground in such a wet season as 1917–18 or so dry a one as 1912–13. Pupae placed in a calabash of sand exposed continuously to the sun failed, but in travelling they worked right down under the sand in any case and many of them showed definite crushing by it. It is worth noting that in the moister situations (in the vleis) practically no trees grow except on the ant-heaps, consequently logs and other dark hiding places are relatively seldom found there. Otherwise it is probable that pupae would have been taken there more frequently.

One other condition should be mentioned. The vast majority of the pupae were in the nearest suitable hiding place to a spot in which big animals had been lying down—buffalos (mainly), wart-hogs, hartebeests, etc. This seemed to accord with the fact that we ourselves were attacked by feeding flies (as opposed to males utilising us as vehicles) mainly when we were stationary and especially when we were squatting down searching for pupae. Again, of two sand-streams, otherwise not dissimilar, one that was used as an occasional game path yielded a number of pupae; the other, used only by small carnivora, yielded only one pupa—in a highly placed hole where a duiker had lain on the edge of the bank just above. It was frequent for the puparia to be near ant-heaps, but this was the result of the fact that the buffalos had chosen the sheltered sides of ant-heaps to lie on during the rains.

Provided that the hiding-place itself afforded shade to the mother, overhead shade (as an analysis showed) was a matter of complete indifference, and the ground in which puparia lay was commonly reached by the sun during part of the day.

The puparia were usually close beneath the surface of the earth, and the evidence suggested that the maggot had wandered but little from where it was dropped. Under each log was usually harder ground, interspersed with softer pockets where babblers (*Crateropus*) or small mammals had previously scratched. The puparia tended to be congregated in these pockets, but they appeared in some cases to give evidence also of gregarious settling by their mothers.

I carefully identified all logs, old or fresh, under which puparia were found and was most interested to note that the very great majority of them were of two species, chiwhanga and mukarati (*Ormosia angolensis* and *Burkea africana*), which were by no means the commonest trees in the woodland. It was not that the fly chooses these out, for all evidence (and there was a great deal) showed that it goes after feeding to the nearest shelter, in some cases very diminutive. The reason was that these are actually the commonest logs on the ground, and they are so because they are the most durable timbers present and also do not readily burn. Some of these logs had quite likely lain for twenty or thirty years, very gradually dwindling, whereas a fallen *Brachystegia* may disappear in three. The eventual exploitation of these areas will result in the early clearing out of these two useful trees (the *Ormosia* for fencing posts) and the consequent confinement of the fly for its log breeding places to species that are attacked by insects and burn. This is one of the various facts that show how concentrated human activity assails the fly from several different directions.

The localisation of the breeding centres in this area suggests that the possibility of attacking the fly on the lines suggested by Lamborn might require consideration. Some of the logs at the Kanyezi vleis that were cleared by me of pupae at the end of my first visit (early July) had already many fresh pupae under them when I came back at the end of the month, where hartebeests had been present. Breeding was going on both in June and July and in some quite cold weather, but emergences from the pupae secured only began taking place in numbers with the advent of really warm weather in early September, and continued into November. The pupae, like those of Lepidoptera, will apparently stand a small amount of damage. Out of 15 that I put aside as damaged in the finding on 30th July two afterwards produced flies.

Glossina brevipalpis.

I obtained no live pupae of *brevipalpis*, but found a few batches of pupa-cases in the *Brachystegia* bush on the Buzi east of Spungabera, one of which contained nearly a hundred puparia. In the case of this fly the batches were beside lying places of buffalos and wild pigs, and the flies at the moment of dropping the maggot had in the biggest find (Pl. xiv, fig. 1) evidently been resting for the most part on the undersides of the coils of large rough lianas (*Cissus*, *Landolphia* and *Bauhinia*), apparently favourite resting places. Some of the puparia were found under logs and some of the replete gravid females taken during the bush-pig incident (p. 337) were resting on the lower surface of fallen *Uapaca sansibarica*

stems, under which the pigs had been lying. The ground (shale) was in two cases exceedingly hard and compact, but humus was present in the situations in which the pupae were found. There seemed to be no such localisation of the breeding centres as I found with *morsitans*.

Glossina pallidipes.

I have referred to the puparia of this species elsewhere (p. 346). They were taken with those of *G. morsitans* and under the same logs, but in very small numbers indeed. None were found west of the Sitatongas.

Glossina austeni.

I have already given some details of this species (p. 348). The very distinctive puparia were all under four logs. One, more or less rotten—with only two puparia—was beside a game path used by bushbucks and waterbucks. Another with 30, showed many blue duiker "forms" about it, but these were too recent; leaf-carpet does not preserve traces well. The third, with 23 puparia, was also in dense shade and exactly at the junction of the primary-type forest and some heavy *Markhamia* bush (mubfeya). Right up to the log, in the latter bush, were the old tramplings and lying places of elephants. A similar log in similar shade lay 18 yards away; it was away from the tramplings, etc., and covered no puparia. The fourth log is described sufficiently elsewhere (p. 349).

XV.—Net Experiments.

Resting Surfaces.

When studying *morsitans*, and, later *brevipalpis*, I erected (Pl. xv, fig. 2) a large mosquito net, 9 feet high, over cut-back tree-trunks, shrubs, etc., and furnished it with stems having different kinds of bark, stones, etc., in order to study the resting habits of the flies. These I turned into the net in some numbers—well over a hundred in the case of *brevipalpis*. Some *pallidipes* were also included in each experiment, and each was continued for from three to four days. None of the three species used confined themselves to the few feet next the ground; they settled, colour conditions being correct, up to the full height available. I have noticed unconfined *morsitans* resting up to at least six feet from the ground.

The rough-barked stems were selected in preference to the smooth, and large and small holes in the trunk and grooves in the bark were freely utilised for hiding in. A completely smooth-barked trunk was entirely neglected. *Diplorhynchus mossambicensis* was a favourite with the large tsetse, and a distinct colour-harmonisation took place also, the blacker tsetses (*morsitans*) choosing blacker bark, the greyer grey bark, the brown ones (*brevipalpis*) brown bark and the underside of rough or knobby lianas, on which they easily passed as one of the knobs.

For the *morsitans* experiment, in pyrophytic wooding in which the trees always show, on one side especially, blackening by the grass fires, the *Diplorhynchus* trunks were specially selected on account of the strong contrast between the colours of their two sides. Shade conditions were about equal (as the result of overhead shade) and, the position of the branch being also suitable, the female flies in particular always tended on settling to select the blackened side. On this side, furthermore, they settled chiefly where the black of the raised cork ridges alternated with pale

brown grooves and this was at 3–4 feet from the ground. Below this area the bark was uniformly black, above it rather more uniformly pale and uncharred. The females also settled, the colours being right, mainly on the lower side of a branch or log, the males settling as frequently on the upper sides. A raised stone and clods of earth were also used for resting under in the *brevipalpis* experiment. Leaves and thin twigs were used by active, not resting flies; these flies were readily disturbed. The majority of the *brevipalpis* remained quiet during the heat of the day, but began to move freely and to buzz against the gauze at sunset. It was then chiefly that this fly, including its females, settled appreciably on non-protective surfaces—leaves and twigs, etc. Those definitely at rest on protective surfaces on the other hand, or in holes, were hard to flush, some (females, and particularly more or less gravid or replete females) even allowing me to tap on the bark beside them. The excellence of their concealment was shown when I finally cleared the net. Both I and two smart natives searched every inch of its contents most thoroughly, as we thought, until we could not find another fly. I then passed my hand over the various surfaces and in this way flushed four more flies, all females, from the *Diplorhynchus* trunk. It would seem that Bagshawe's suggestion—that fly does not haunt shady papyrus on account of the contrast in coloration—may well be correct.

A certain number of flies were generally to be found on the net and restless; these were always males. When the net was cleared and the flies examined one by one this observation was fully confirmed. The hiding flies were mostly, but by no means entirely, females. From my observations in the field also, it seemed clear that in *Glossina*, as in so many other animals, the female trusts mainly to concealment for defence against enemies, the male more largely to activity, and that the difference in the requirements of the sexes and their methods of meeting them is the chief reason for the female's special seclusion, though Lamborn's factor (avoidance of males) may be operative also. The smallness of the meals usually taken by the males in the field—commonly mere snacks—bore a relation no doubt to their need for activity; not so much to relation to enemies, for the male flies were quite capable of hiding, if necessary, but in relation to travelling and the capture of females. It seems certain also that the males need for food must be far smaller than that of the female. The results generally suggested the consideration of a contributory method of fighting the fly which I shall refer to below (p. 379).

Distance of Attack.

Another point tested was the distance from which *brevipalpis* and *pallidipes* will attack passing animals. It was undertaken at the end of my stay and I was unlucky in the matter of wind, light variable airs prevailing during the main experiment. However, rushes to the side of the net next the cattle occurred at 6 and 8 yards distance, and once, just before sunrise, at 18 yards, the shrub growth that blocked the view on this occasion showing clearly that it was a matter of scent. When the net was to windward of the cattle no general excitement took place, though a very few flies might fly towards them. The short distance from which attacks by *brevipalpis* took place in the sunny hours was illustrated in my clearing

experiments also. If I was right in believing that in the experiment on the Inyamarimu (described fully on p. 373) the individuals of *pallidipes* that attacked the cattle did so from outside the clearing, the small number that came to the cattle compared with the considerable number of these flies outside suggested that about 30 yards may be the extreme limit of this fly's attack under favourable conditions.

A live goat tied inside the net attracted little attention. The flies bit occasionally, but allowed themselves to be driven off easily, and none fed to anything like repletion, yet the two oxen, when brought close up to windward, always attracted a great rush, even on the part of females that had been resting quietly on protective bark surfaces and had not been in the least attracted by the goat. I should say that I was myself much more readily attacked in the net than the goat. The liver of a cow was also not specially attractive.

XVI.—Natural Enemies.

During my first week at the Kanyezi vlei I was camped 150 yards or rather more from a considerable cluster of male flies. These were preyed on daily,* sometimes continuously and for a long time, by half a dozen to eight birds belonging to three species—*Dicrurus afer* (African drongo), *Bradyornis ater* (mimetic fly-catcher) and *Bradyornis murinus* (mouse-coloured fly-catcher). From the continuous nature of the attacks, and the immense number of house-flies (*Musca domestica*) that tame drongos of my own have shown themselves capable of devouring in a very short time, there could be very little doubt that the birds were making considerable inroads into the male fly population, and it was likely that the practical disappearance sometimes of this cluster was in part due to them. The birds perched on the low trees bordering the vlei and dropped to the tsetses in the grass below.

In my general experiments I found that many birds disliked Muscid flies, including *Stomoxys*, replete or empty (actual *Glossina* not tested), but that drongos, fly-catchers, stonechats, swallows, bee-eaters and some commoner small searching birds (*Crateropus*, *Phyllastrephus*, *Apalis*) liked them much; drongos and swallows (certainly also fly-catchers) continued to feed on them when so replete as to refuse all non-Dipterous insects. The digestion in at least two of these last three groups is so rapid that (in my experiments) even when the birds were replete three or four minutes' rest made room for two or three or more flies. These birds must be relatively formidable enemies to a fly the males of which display themselves so freely, and it is a pity that the population of such enemies must be limited by the dry season food supply. I have sometimes seen swallows hawking continually after insects on grass-stems and grass-blades, picking them off while flying, so that male *morsitans* is a likely enough object for attack by these birds. Birds are in the habit of paying special attention to insects, otherwise acceptable, that are present in numbers together, so that in localities in which male *morsitans* is being kept scattered by the presence of much game it must lose a far smaller proportion of its population through the attacks of birds.

* The presence of the birds at this spot was noted practically daily; they were only continuously watched on about two days.

Crateropus kirki (Kirk's babbler) and the two guinea-fowls, *Guttera edouardi* (crested) and *Numida mitrata* (East African), were observed once or twice (out of many times) scratching in positions like those in which tsetses deposit their larvae, as was also the bristle-necked bulbul (*Phyllastrephus capensis*).* A more interesting observation was made on an elephant shrew (presumably *Petrodromys tetradactylus*) in a dry but shady donga entering the Buzi at the south end of the Sitatongas. We had searched for and found puparia (*austeni*) under a large fallen tree and, going on to search under other logs and stones, found we had been anticipated by a small animal. For a distance of 47 paces along the donga every hiding place that would have been used by tsetse had had the surface soil scratched out and the spoor and the droppings were, I should say (and the natives also were certain), distinctly those of one of these elephant shrews. I have actually watched the above elephant shrew in the wild state scratching thus for slightly buried insects and, having kept individuals in captivity, am familiar with their droppings, etc.

The natives stated that ox-peckers (*Buphaga*) regularly prey on tsetses that are feeding on game animals, and that from the movements of the birds it is obvious that the flies employ against them the sidelong movements I have referred to in relation to attack by knife and assegai. The flies also no doubt continually come within the ken of the birds that carefully search tree-trunks and twigs, and it is no doubt in relation to these that their choice of protective resting surfaces is of use. Such birds form a very large proportion indeed of our small bird population.

Spiders of various bark-haunting species that hide in crannies and leap on their prey accounted for a number of the flies I had under observation in the net, and it is probable that these are the female tsetse's most important enemy. One tsetse (*morsitans*) was seen caught in the net of a web-making spider. Dragonflies on several occasions in fly country inspected the backs and necks of my companions. A wasp once did the same. On one occasion, travelling from the Buzi to the Mtshanedzi, five *brevipalpis* were under the cattle, four being under the leading ox. We ran into some dragonflies, which at once began passing to and fro immediately under the belly of that ox. I saw no captures, but these four *brevipalpis* had disappeared when the dragonflies left us. The one survivor travelled with us for over one and a half hours and remained about our camp for long afterwards. Dragonflies were exceptionally and extraordinarily numerous in 1918, but the tsetse population remained large. I do not remember seeing any ASILIDAE. They only become abundant here in October.

XVII.—TSETSE CONCENTRATIONS.

My closer observations on this subject, which may be of high practical importance, were limited to a single *morsitans* centre, but I searched and studied much country in which there was no concentration, both before and after the commencement of leaf-fall, and secured much native information also. I obtained, I believe, a fairly clear idea of the conditions obtaining in this particular fly-area. I spent a fortnight in all at the Kanyezi fly-centre. This was a large and very definite breeding

* The existence of soft pockets of earth, breaking the harder crust under most of the logs examined, constitutes indirect evidence also of the scratching of some animal or animals in these places.

concentration in country relatively devoid of the fly. Secondly, my native expedition reported coming across several such concentrations north of the Lusitu, with the same male crowds at the edges of similar vleis, the same ease in finding puparia and the same relative dearth of tsetses in the similar country between. They brought me both *morsitans* and *pallidipes* and puparia of the former. Thirdly, the Masando vleis and some vleis east of the Mapapa (see Map) were both stated by the local natives to be the sites of concentrations, how great I do not know, and to have been so in the present season. I had myself found a concentration at the Masando in 1900, but in 1918 we found the flies on the grass of the vlei-edges only in parties of three or four—as at Kanyezi's, when a male crowd had been dispersed. Buffalos and elands were present in small parties. We were led to the more easterly vleis by a native (subsequently in my service and apparently reliable), who stated that he had seen the flies there in great numbers only a week or two before. I had no cattle with me and only two flies were taken, but a large herd of buffalos had arrived meantime. These two sets of vleis and Kanyezi's are all within a very few miles of each other.

Leaf-fall Concentrations.

When I left Kanyezi's on 1st Augsut it seemed likely on the whole, though uncertain, that this scattered, unconcentrated fly was even somewhat sparser than it had been in June. The few that the cattle picked up on that particular day were at vleis or glades—not that this was unusual. Natives on the Umvuazi River had reported an increase in the flies about their villages, and one way in which the insects might travel thither appeared to be illustrated by the fact that the flies that were attaching themselves to us left us (one of them after following for $5\frac{1}{2}$ miles), not in the rather barer bush, but on our reaching the somewhat shadier wooding beside streams. The natives stated that this tendency to collect at the streams becomes more marked rather later, but not (Kanyezi said—and I think we saw) at the expense of the vlei population, which also increases.

The natives attributed the streamward movement of the fly in the later dry season to the fact that the general drying up of the country forces the game thither. "The int-hesi then congregates there to feed on the game." While this explanation is not quite accurate, it is certainly to be judged from what I have said above that game, or natives, either going to the streams or merely travelling across them, will tend to deposit there at this time any flies that they may have picked up either in the drying-up country generally or at vleis, etc. These leaf-fall (and soil-moisture ?) concentrations, whatever they may amount to here, are evidently to be distinguished from the more permanent breeding centres, although these also will doubtless receive accessions from outside at this time.

Primary Concentrations.

That the concentration of the fly in the last-named centres is not purely the result of dry season concentrations there of the game seemed certain. There was no concentration whatever of the game at Kanyezi's vleis, where I stayed a fortnight in all and at which fly was plentiful and breeding, nor had there been since the rains. There was even less of a concentration at the Masando in June 1900, when I found

tsetses there in great numbers and very troublesome, but could find nothing to shoot. The concentration (in this case merely the arrival of a large herd of buffalos) at the more easterly Mapapa vleis in 1918 took place when the flies were (according to the natives) already abundant there, and the small parties of buffalos that were apparently keeping down the numbers of the visible fly at the Masando in 1918 could hardly be described as a concentration. It was certain from the detailed distribution of the large number of muddy puparia taken at Kanyezi's vleis that the fly concentration was already in being here in the late rains, when also a great buffalo herd was temporarily present; and as my flies and pupae were indubitably largely the descendants of the depositors of these puparia, it might be said that fly concentration found in the dry season may be the result of game concentration either then or previously. Even this (as accounting for the presence of a fly centre, apart from the mere question of its population) was negatived by the native statement that this fly concentration is permanent though variable in numbers, that it had been there before the buffalos came (as it had also survived their departure), and that the animals had stayed a very few days only. In testimony to the great size of this herd my guide, Kanyezi, who lives near and had seen them, pointed out strong paths that had been beaten out and vleis that had been heavily pitted with spoor in a single day. The natives said that the other centres seen or heard of by me were also present each dry season, though again with a varying population. The conclusions that I would draw from all I saw and heard, including the fact that away from these centres we failed to find any but very stray pupae, even when buffalos and other game had been abundantly present, are that what Shircore has called "primary centres" undoubtedly exist; that their actual (not their apparent) population no doubt varies with the immediately preceding food supply; and that in their situation beside vleis they have hit off the best obtainable combination of the three *desiderata* of food, moisture and shade (for vleis, generally speaking, and their neighbourhood are attractive to game and other animals, and the wooding bordering them is quickly back in leaf). It is even possible (in an area in which *morsitans* happens to be dependent on the larger mammals) that a kind of selection is continually taking place by which those vleis that for any reason have become neglected by the game for a considerable period cease to be fly centres. It was certainly strange that Gundoda's vleis, well watered, midway between Kanyezi's and the Masando and quite near each, and in the same wooding, uncleared, but carrying a human population and a more permanent shortage of game therefore than the others, should have been shown by a fairly exhaustive examination to be practically devoid of pupae and to have produced few flies. Some of these few, latterly, were marked flies released by me in the Kanyezi vleis, and it is likely that the great number of flies said to be at Gundoda's in the rains come first from this and other vlei series.

Village Concentrations.

A concentration of another kind than the two referred to above, and presumably one of a very shifting nature, is that which appears to take place at native villages, even in the rains, and particularly whenever the fly is abundant. Gundoda (whose village, besides affording good shade and being situated at the edge of a well-watered vlei, is a tempting dismounting-place for fly) described to me well how in the

spring and early rains, as they would be sitting in the shade by the water, attended it might be at first by a merely reasonable number of tsetse, every newcomer or passer-by would bring with him an accession of flies till their numbers became unbearable. Some would go again with departures, more would stay, and they tended to increase in numbers from day to day. At that time every one, sitting or travelling, carries a leafy switch and uses it incessantly. The probability that the great majority of the flies of these village concentrations are males was suggested further by my failure to find puparia at Gundoda's.

Leaf-fall in relation to Concentration.

It would seem that in one of the three forms of concentration I have referred to, leaf-fall must be a highly important factor. That there are other factors producing concentration is however certain; for on my first arrival in the *morsitans* country in June, concentration at the vlei centres was already in full operation, yet leaf-fall (the season being late) was not yet noticeable. The same would apply to my visit at the end of May and beginning of June in 1900, when also high concentration was present. When I left on 1st August 1918, leaf-fall was in many places producing a visible effect, and it is possible that this may have brought about the apparent increase in the numbers of *pallidipes* at the Kanyezi *morsitans* centre. Otherwise things had not, to all appearance, been so very different in June from what they were in August. Whatever the factors that bring about these "primary" concentrations, the possibility is suggested that measures against them might not have to be confined to the very brief period of maximum leaf-fall. All would really depend on the value of the "scattered" fly for the local survival of the species, and I am inclined for the moment to suspect that this may be greater in the case of *pallidipes*—everywhere seemingly a rather scattered fly—than in that of *morsitans*.

The Kanyezi centre was certainly, to judge from its puparia, a focus of *morsitans* rather than *pallidipes*, and it is conceivable that these primary centres may be a vital point in this fly's social organisation.

The rural population of *brevipalpis*, as I saw it, was much heavier and more evenly distributed than that of *morsitans* and therefore less easily distinguished from its rather more populated patches, in the primary thickets. In a less generally suitable area (such as the granite-gneiss actually is) or in a season (if such occurs) which really stripped the *Brachystegia* wooding of the "Oblong," it would doubtless undergo leaf-fall concentration.

XVIII.—The Recent Outbreaks of Nagana in Mossurise.

The fly, driven from a large piece of deciduously wooded country by Umzila's measures, never greatly abandoned its permanent haunts except on the Sabi and in the cleared portion of Gogoyo's, the Mwangezi, etc., and within 7 or 8 years after the relaxation of the measures in 1889 it was found re-occupying its old (and its present) wet season quarters in so far as bush conditions and travelling facilities then allowed. Since then, within my own observation, the wooding of the heavily deciduous areas has increased greatly, and areas close to the British border that

18 years ago were relatively bare are now very fully wooded and capable of giving a temporary support to tsetse.

Up to a very few years ago cattle were still kept successfully in Mossurise within a few miles of the British border from the Puizisi to Maruma, and from Spungabera to the Inyamgamba. These, except the Spungabera cattle, which have suffered, have been largely wiped out by successive attacks of nagana, especially during the last three years. At the same time isolated outbreaks, here and there, have taken place on farms just on the British side of the border. In a remarkable proportion of cases a connection has appeared to exist between the outbreak and the wanderings of buffalo.

The incursions of buffalo into the cattle-carrying areas have undoubtedly increased greatly in the years concerned. The northern outbreaks coincided with or followed the invasion of Mafusi's country by considerable numbers of buffalos from the south and their coming in contact with the *brevipalpis-pallidipes* area there. In the section opposite Spungabera (across the Buzi) these animals are certainly far more in evidence, and in far larger numbers, than they were some years ago, as I know from shooting trips on the Upper Mtshanedzi in 1901 and 1902.

Elands have also greatly increased, as have pigs; and it is likely enough that the fly itself has increased within its permanent haunts in consequence of the great and progressive increase in its food, and of the earlier burning of the grass. This would contribute to the menace, and it is by no means incompatible with the fact, of which I am convinced, that such destruction of the big game as might be easily feasible would not alter the fly's permanent boundaries, though it would certainly prevent it from being carried into contact with the cattle.

The great increase in the wandering game has undoubtedly been the main factor in the outbreaks of the past few years. But it may be said that it is especially hard to distinguish the separate original infections where natives' cattle are concerned, owing to the likelihood of infection by mechanical transmission by other biting flies that is incurred through their placing the survivors in the herds of their neighbours, and by their movements of cattle in connection with their matrimonial affairs.

XIX.—Clearing Experiments.

These were carried out only to ascertain the effect on the fly of the clearing of undergrowth (Pl. xvi).

Experiment 1. *To ascertain the effect of clearing the undergrowth in primary forest.* The whole width of the dense undergrowth of the Inyamarimu forest strip was cleared to a length of 80 yards. The width varied from 40 to 70 yards. It was incidentally open to penetration and passage from the sides by any flies there might be in the *Brachystegia-Uapaca* bush on either side of it. At 11.30 on the following day the two oxen were driven into the middle of the clearing. They carried in with them one fly, a male *brevipalpis* picked up in passing near some of the uncleared bush, and this was at once removed. They were stood in the centre of the clearing and from time to time moved across it a little though not to its edges. They had been placed many times before in this spot and had never failed to be attacked by large numbers of *brevipalpis*. This time in three hours only four came to them.

G. pallidipes and *Tabanus* had never before been noted on them in this dense wooding, though they occurred in the bush outside. Yet in these three hours nine *pallidipes* (all but one females) and 31 *Tabanus* were taken on them.

I then turned the two oxen just into the uncleared undergrowth alongside and they were at once attacked by *brevipalpis*. My collector captured 15 on one of them here in fifteen minutes and no *pallidipes* or *Tabanus* were seen at all.

The effect of clearing the undergrowth alone in banishing the big fly was, I think, well demonstrated. It is perhaps more likely that the other flies were attracted to the cattle from the bush outside than that they had taken up their abode in the forest as the result of the clearing of the undergrowth. This would suggest that attacks of *pallidipes* in the sunny hours are undertaken from a greater distance than those of *brevipalpis*, being equivalent rather to the latter fly's evening attacks.

Experiment 2. *To ascertain the width of undergrowth clearing necessary to protect a strip of road from attacks by* brevipalpis *in sunny weather.* In *Brachystegia* bush on the Buzi, the cattle in passing along a certain track four times in all had on each occasion been attacked by *brevipalpis* all the way along from the thickets passed closely or passed through. I cleared the dangerous undergrowth, but none of the overwood, for a paced length of one mile and a width of 25 to 40 yards with the track in the middle. I left three small points not fully cleared—some small *Diplorhynchus* trees with low-hanging branches and *Bauhinia*, a small primary-type thicket, and a piece of uncleared sapling growth. I put the cattle through and they were attacked at the first two of these places—nowhere else at all. I brought them back just outside the clearing and they got flies all the way. In the afternoon, having cleared these spots, I put them through again, bringing them back this time along the track. They got no flies at all either way until driven out beyond the cleared strip at each end. They were then each time attacked at once.

It was to be expected that this narrow clearing would be of use only in sunny weather and this point was tested later on an overcast day. The cattle were driven along the cleared mile and 32 *brevipalpis* were taken at them, coming in all the way along. They still failed to be attacked here in sunny weather.

Obviously then, very little clearing is needed to safeguard a given piece of road from this fly, provided that the cattle pass along it in sunshine. A considerably wider clearing would be needed to render it safe at all hours and in all weathers.

Clearing by Arsenite of Soda. I had previously carried out successful experiments in poisoning with arsenite epiphytic figs in forest on my own property. This suggested its use in clearing for tsetse, for the difficulty in ordinary axe-clearing is that the stumps at once (and repeatedly) send up fresh growths and form coppice that is even more suitable for the fly than the growth cleared. A recent examination of some of my experiments shows that the strength of an ounce of arsenite to a pint of water (the maximum strength tried) is insufficient to be generally effective, though it killed some trees and inflicted damage on many others that may enable the fires to burn them out. I hope shortly to be in a position to state the best strength for this sort of work. Given this and the amount of liquid required per acre for particular kinds of bush, one can estimate very roughly the cost of this kind of clearing.

Mere ring-barking—with an upward-pointing frill—is required instead of cutting down and this will economise part of the extra cost of the arsenite.*

The balance of extra expense will doubtless in particular cases be justified by the fact that the work will not have to be repeated, but it will be seen that where great areas of dense undergrowth are concerned this will be considerable. Naturally cattle should not be run where arsenic has been used in the last few months.

XX.—Measures for the Control of Tsetses in Mossurise.

The parts of the Mossurise district which are more especially suited to white settlement are the two dolerite areas (*a*) that between the Lusitu and the Mtshanedzi, and (*b*) the Gwenzi country from Spungabera to Mount Singunu. These areas would split up into a very great number of 1,000 hectare farms, practically all good. The soil is for the most part rich and particularly adapted to Arabian coffee (a good close settlement product, if the labour should be sufficient), the natives raise fine crops even when crops are more or less of a failure elsewhere, the rainfall is considerable and reliable, and a good deal of local labour is available; the grazing throughout is good and the grass early. It was pitiable to see my bait-cattle being followed for miles like a circus by the children of some of the villages we passed in a country that should be carrying its thousands of head. There are good permanent streams everywhere.

If there should be an unwillingness to sacrifice the Mafusi rubber forests—which will always carry fly and be a menace—there might still be a large number of farms in the remaining area. If the outlet to a market is not through British territory, there is, for produce, the Lusitu-Buzi waterway investigated by Snr. Roma Machado and capable of being opened as part of the settlement scheme. The eventual creation of a safe winter route for cattle along the south of the Buzi is also not improbable.†

The Umzila results, already described, show clearly—and it cannot be too much emphasised—that *settlement properly planned will protect itself.* As settlement is bound to be the eventual policy, no matter how long deferred, it cannot be said that the ultimate future of the more delectable of the Mozambique Company's infested areas is necessarily seriously compromised by the presence in them now of fly. Umzila's results even suggest that some day in the very far distant future the question will be settled by the natural increase of the now protected native population. "Properly planned" settlement in fly will not consist in the giving out of isolated farms, scattered over the face of the country. The failure to keep cattle at the Dysart Concession is a case in point.

There must be a definitely planned settlement scheme, affecting a large block of country together, on some sound agricultural basis. The closer the settlement can feasibly be the better, and first and foremost amongst the conditions of occupation must stand the effective clearing of the less freely deciduous types of woodland.

* I have tried boring, both by auger and by down-slanting strokes with a narrow native axe, but find that this leaves unaffected areas of bark between the holes and kills only particular branches, the poison (as might be expected) taking effect in a vertical, not horizontal direction.

† Later information suggests that the Sabi even now offers a safe route.

These will be inferred sufficiently from what I have said in this report, but I will add here that in the piece of country in question, along the streams and rivers and in larger blocks on the Lusitu, first-class timber trees —mahogany (*Khaya*), musando, mowana (*Adina*) and others—are present in quite unusual numbers. These, floated down the Lusitu, might in some cases help much to defray the cost of clearing.

Secondly, no ingress of large game must be allowed from areas still under fly. The best barrier—with the elephants away—might be a strong, patrolled fence; but if the fringes of the area are sufficiently closely settled it is likely, even from our present imperfect success on the lightly settled border, that this fact alone, with shooting, will suffice to keep off the elephants, buffalos and elands. It is these three animals that probably chiefly matter.

Umzila's principle—the settling and clearing of the low-lying guard-area only, the enclosed hill mass then taking care of itself and being perhaps disposed of later at an enhanced value—would be well worth consideration and investigation. Under such a scheme, carried out with thoroughness, it seems at present fairly certain that cattle could, after a few years, be kept safely and in numbers on the dolerite.

If, on the other hand, the settlement should have to be a gradual growth from small beginnings, its safest base would be the deciduous part of the British border, a block at a time being settled and special measures being taken against the buffalos.

The settlement of the two permanent fly-areas themselves would mean the end of the menace. The great strip on the Lusitu that is now occupied by rubber forest, both east and west of the river's southward turn, represents some of the finest agricultural ground in the country and is in immediate touch with the Lusitu-Buzi waterway. Much clearing is necessary, but the farms here could be small. The "Oblong" offers greater difficulty. The soils on the whole are distinctly useful, though less rich than in the other *brevipalpis*-area, but there is relatively little permanently running water away from the big rivers. Pools, however, persist in most cases and water should be obtained in this formation at no great depths by boring and sinking.

XXI.—Discussion of General Methods of Tsetse Control.

Game Destruction.

In view of the evidence I have already alluded to (p. 336 and elsewhere) we are bound to keep an open mind with regard to the possibility that even *G. morsitans* might survive the destruction of all large mammalian life. Yet the fact that under present conditions game-paths are the regular rendezvous of the sexes, and that the connection with game appears generally to be an essential point in their rather complicated social scheme, makes one hesitate to reject the alternative view. Lamborn (Bull. Ent. Res. vii, 1916, p. 37) has argued well for the view that it need not be a large game population that will support fly, and this might be a sufficient explanation of Umzila's continued trouble in the rubber forests.

In a relatively clean-stemmed area like that on the granite-gneiss, in which also bush-pigs are not over-abundant, it is to me very conceivable that wholesale game destruction might banish the fly. An obstacle, however, would be that the whole territory is one vast game area, so that the game would pour again into a given section of it as soon as the persecution was relaxed—unless an effective barrier

were created such as could probably only be made a permanency with settlement behind it. Whether the returning game would bring fly in again would depend on (1) whether the whole continuous fly area had been cleared of fly, or (2) whether the portion cleared had been split off from the uncleared portion by an effective barrier against the fly itself.

West of the Sitatongas the country is much more jungly, and wholesale game destruction is proportionately more difficult. In addition this country abounds in bush-pigs, which are difficult to destroy and which in anything approaching their present numbers can probably alone support the fly, with baboons, abundant cane-rats and other animals which may all contribute to its sustenance. I consider that it will be impossible to starve the fly at all generally by ordinary game destruction here, at any rate before the country is very fully settled, though buffalos and elephants might be banished by adequate and persistent shooting.

What can be done is to protect particular places, like Spungabera and the British border, that are outside the fly and are threatened only by the wanderings thence of the bigger game. Fencing, the judicious placing of native kraals and shooting are amongst the possible measures, and organised and repeated drives might be undertaken locally. I have suggested similar means of keeping the fly from being carried into any areas that may in the future be settled.

Again (*cf.* p. 355) it seems to me that game destruction should check the *advance* of a fly-belt, whatever its effects on the ground already infested. No problems are at present better worthy of study than these—(1) the extent to which tsetses will travel independently of game, and (2) the distances that the female will travel *on* game.

An Attack on the Concentrations.

At first sight, the weak point of *morsitans* in the area in which I have seen it would appear to lie in its most striking attachment to the vicinity of more or less moist spots and in the great numbers in which it breeds there. One is strongly tempted thereby to suggest that for areas in which this is the rule further experimentation should be carried out on these distributing, and probably receiving, centres; experiments in local clearing of varying widths, in planting vleis and their margins with the heavy wooding avoided by *morsitans*,* poisoning and gassing the male clusters (torpid on dewy mornings) and the bush just immediately adjacent, catching with the aid of cattle, pupa-destroying or any other methods against either sex or either stage however remotely promising, suggest themselves as worthy of trial before the idea of attacking *morsitans* at its concentrations is finally given up.

The essential point to ascertain, however, supposing such measures to be capable of exterminating the fly at the concentrations, is the value or otherwise of the "stray" flies (which comprise both sexes) for the survival of the species, and whether these would continue indefinitely to escape the measures applied at the centres—always supposing that, in the area concerned, they are not and cannot be driven in

* To check radiation, introduce shade conditions inimical to the fly and spoil the game's early grazing, also if the trees that succeeded were of a definitely "drying" type, like Eucalypts, to help to dry the ground. Such a measure, even if locally successful, would doubtless be too expensive to use except under special circumstances.

completely by leaf-fall or simultaneous burning. It would be difficult to ascertain their value until one had already successfully applied the local measures.

There are other difficulties also to be faced in dealing with the individual centres. Their probable large number in a given area—though in the area visited they occupied only a small number of the places that appeared suited to them—gives rise to difficulties (1) in relation to finding them all, (2) in relation to the number of white workers that it might be necessary to employ when simultaneity seemed important and time short, as in work that might be planned against the emerged flies. Here the period when emergence is already rapid, but the fly not yet greatly scattered, might be of special importance. There is also the fact that the game must first be banished from each centre before the flies will present themselves for treatment in anything approaching their full numbers.

Broader lines of work are undoubtedly preferable if any should be found effective, and it will be most interesting to see the result of the Southern Rhodesian Government's present measures against *morsitans*, planned, as I understand they are, on game removal and large measures of bush destruction.

To discuss one or two of the points, nevertheless, it may be said that the great reinforcement of the visible fly sometimes called out by the presence of my cattle showed that ordinary collecting by hand is a very inadequate method, especially with game about. Collecting round cattle would be far better, but their length of life under continual attack is a point to be considered in relation to the financial feasibility of the scheme. It might well be prolonged by antimony injections, but would otherwise (to judge from my experience) be a matter of a very few weeks indeed. Better still would it be if the flies coming to the cattle could be automatically poisoned. The effect of frequent arsenical spraying, although it seems quite unlikely to be useful, might be tested experimentally, for it has not been my experience that a tsetse keeps its proboscis buried to the bulb all the time it is feeding, and a possibility I have referred to elsewhere (p. 341) might also be worth a trial.

If the breeding concentration seen by me at the Kanyezi centre should be typical, it suggests that in areas where such concentrations are the rule it might be possible to devise useful measures against puparia. Artificial breeding places, unless scattered nearly as freely as the present fallen logs, though with a regularity that would make them more easily found, would not, I think, be useful; for my indirect evidence all pointed to the probability that the heavily pregnant female does not fly many yards from where she last fed.

The present situation at Gundoda's vleis suggests that the placing of Kafir villages at the fly-centres might break these up through the effect on the game, but with so many apparently eligible sites vacant the concentrations would presumably reform elsewhere. This measure alone would only be useful if it were possible to plant a population at such places through the area generally.

So far as *G. brevipalpis* is concerned, the observations spoken of on p. 351 would require to be greatly added to before we could assume that this fly's permanent boundary could be put back merely by the splitting up of the bush on its western margin. The point is worth looking into further. In any case the game would require to be destroyed or excluded in order that the fly might not be carried back in the rains.

Assistance to Natural Enemies.

Natives destroy great numbers of birds, in both the adult and nestling stages, but I fear it would be impossible to make protection effective. It perhaps matters less here, as the native population is in parts not great and in the "Oblong" it is almost non-existent. The same difficulty applies to elephant-shrews which are greatly trapped. It is a pity that these useful animals cannot be protected, the more so as they are put to death in a peculiarly cruel manner.

Rewards for the skulls of small carnivora brought in might be useful in better populated fly areas, probably not here. There would in any case be a doubt whether the natives, who trap freely for these animals already as articles of food, could be stimulated very much more by a prospective reward. The greatest enemies of nestling birds here are the tree-snakes (*Dispholidus*) and probably the only effective remedy against these lies in severer fires.

Indirect assistance to birds would take the form of destroying trees, etc., the bark of which is specially protective to the tsetses. This method is inapplicable to *morsitans* and *pallidipes* because so large a proportion of the trees in *Brachystegia* bush have suitable bark, grey and somewhat charred, that wholesale clearing would be necessary. In a *brevipalpis* area the destruction of *Diplorhynchus mossambicensis* and all rough barked lianas would probably be distinctly useful and should form an essential part of any hand-clearing scheme; not but what other species I could specify are of probable use to this fly in varying but usually less degree.

Protection of Stock and Riding Animals passing through Fly.

I have already described my clearing in this connection (p. 374). In addition I found that very frequently the animals were not attacked if the carriers were walking immediately ahead of them, without an interval. I sometimes walked at the head of the carriers myself and then noted flies (*brevipalpis*) coming out to me and turning back—rejection, evidently, after inspection.

Again, when I divided the cattle into two lots (two in front, one after an interval behind—I never had more than three) I found that the first lot drew off all the fly, the last animal commonly getting none.

In the following experiment both these principles were called in. I wished to protect a donkey in passing through the heavily infested three mile strip following the Inyamarimu. I placed two oxen in front; the four goats followed them at from forty to eighty yards behind; then (just behind) came myself and a native, then the donkey with its rider, a native walking in each side of it and one behind; next, at some distance, came a cow. The oxen both carried fly all the way and were sometimes assailed by many; the goats' driver captured a *brevipalpis* on himself, but the goats escaped entirely; one only came to the cow. On emerging from the dangerous bush, the oxen were turned sharply into the grass and took their flies with them, the other animals, which now passed ahead, getting none. The control experiment, if such were needed, had been provided two days before when, on the same path, the donkey was sent on a *detour* to avoid a bad bit of forest. It ran into a thicket and sustained quite an attack and had to be brought back behind the cattle.

This suggests that a mob of cattle might be protected in travelling by placing the less valuable animals a little ahead. Naturally a mob of cattle is a bigger mark

than my animal or animals that marched second, but that *relative* and perhaps nearly complete protection would be afforded I am convinced.

I have heard it stated at second hand from a man who had had some experience of running cattle through fly that it was chiefly the outside animals of a mob that were attacked. It may be possible to prevent even this.

I failed to carry out any experiments in the matter of spraying or wiping animals with paraffin or other deterrent liquids, though it had been my intention to do so. Against *brevipalpis* the animals' lower surface should be sprayed.

When biting flies are abundant it is a common experience to have them attack the cattle at once on their emerging from an arsenical dip. An internal tsetsefuge might, however, be experimented for and be used where the number of cattle was not too large for treatment. During our first epizootic of African Coast fever, in 1900, when I was already losing stock seriously, I tried dosing the surviving cattle each morning with a double handful each of garlic, crushed and given in a bottle of water—as we had then no dipping tanks. I am inclined to attribute the fact that I saved a much larger percentage of our small herd than did any of our neighbours (who lost nearly everything) in part to the deterrent effect of the garlic on the ticks. I do not know its effect in relation to biting flies, but it might be tested, and if it were successful, garlic-eating might become a useful if obnoxious habit in sleeping-sickness areas.

Clearing Measures.

(1). *Clearing by cutting down.* Where not followed up, the good effect of this measure must be very transient, for the stumps quickly produce coppice of a type that is specially liked by *pallidipes* (Pl. [illegible], fig. 46)—or, under shade, by *brevipalpis*. Where, on the other hand, clearing by cutting down is followed by very late annual burning, its effect, very generally speaking, is likely, when the grass is sufficient, to last as long as the late burning is kept up. It is said that a large proportion of *Uapaca* cut down during the rainy season does not grow again. I have no observation on this myself beyond the fact that *Uapaca* trees are more easily killed in native gardens by burning than are various other trees. The reaction of each of our commoner tree species to the cheaper methods of clearing would be worth ascertaining by special experiments.

(2). *Clearing by arsenite.* Experiments that I carried out on pieces of wooding selected as representing an average of a type that was well infested with *brevipalpis* did not suggest that the clearing by arsenite of such continuous *Brachystegia* bush as fills the "Oblong" and runs north to the British border past Spungabera would necessarily run to a prohibitive figure for this class of work, though the full strength to be used remains uncertain. Naturally the clearing of great areas is in any case certain to be expensive.

Superintendence and transport of water, etc., have to be considered. While native police might superintend the actual working groups, general supervision by a European would be necessary both for the efficient organization of the water transport and of the work generally, and because it would be unsafe to leave large quantities of poison in the sole care of native police. The best effects from poisoning would probably be obtained when the sap is up, that is in the spring and summer. Water

would doubtless give much difficulty in some localities in the spring months, but the country generally has water in streams or pools.

It will be gathered from this that poisoning offers certain difficulties in addition to its possible high cost. It could be put into effect most easily and cheaply round a settled station like Spungabera, where there are also mere patches of wooding to be dealt with ; but here the greatest care would have to be taken to keep all stock from treated areas until all possibility of their obtaining poisoned leaves had passed. The method would be still more useful to occupiers of farms under a settlement scheme in the fly, for cattle would not yet be present.

Killing by arsenite, followed by a course of late fires, should be exceedingly effective in removing woodland, and the finality of it, with the fact that it requires vastly less labour than the other radical method, stumping, would be worth the expenditure that a considerable increase in the strength of the poison might entail.

A local point to be remembered is that my observations were carried out in a year in which bush generally tended to carry leaf in the dry season better than usual owing to the heavy preceding rainy season. *Brachystegia* wooding has this tendency at all times, except when exposed to relatively rigorous conditions, but if it should be found later that in certain dry seasons the *Brachystegia*-dominated bush of the "Oblong" generally does become too leafless to harbour *brevipalpis*, the clearing of the ravine-type thickets might suffice—if at any time in the future the hand-clearing of this area comes to be considered.

(3). *Clearing by judicious native settlement.* The first lesson to be drawn from Umzila's results seems to be that we can make a seasonal fly-area safe by broadly (perhaps narrowly) clearing its margin and preventing passage of game.

In the permanent fly-area and portions of another permanent fly-area that he cleared of fly the result was brought about, apparently, mainly by bush destruction, though game also was greatly reduced.

It is perhaps a pity that the humane methods of the white man make difficult the wholesale transportation of populations for the elimination of tsetse areas, even in the interests of the population in question. Our methods would be less wasteful than Umzila's. We should begin with a close botanical and oecological study, and we could produce Umzila's result with a half, a quarter or an eighth of the force used by him.

On a small scale, with such an inducement to settle as the remission of their tax (meaning much to the native, and to the Government a great saving in the cost of clearing by other methods), the plan is still very feasible. When examining the Spungabera problem I was struck by the impression already made in a single season by the native Umgazaza on a piece of wooding that constitutes one of the special dangers of the place. With a few more Umgazazas settled here this piece of wooding would go—at a small cost to the Company. The soil to be cleared is rich, the natives would raise good crops, and they could dispose of their surplus grain a mile away at Spungabera. Other wooding on the Spungabera hill could be treated in the same way.

The pity is that the cultural operations of our natives do not include the taking out of tree-roots. If, however, they left all stumps standing—and they leave a

very great many in any case—these, in secondary bush, could be treated with arsenite by the owners themselves under the supervision of police, who might be sent round with it for that purpose. This should render the clearing permanent—at a cost. Surviving primary-forest stumps are killed by the grass fires after the cessation of cultivation.

(4). *Clearing by regulated burning.* Of the probable good effect of this measure I can speak with an assurance that is based on nearly twenty years of interested observation and experiment; interested, because my own land has been in question, and I have had to study there the effect of early, late and no burning on pasture and afforestation respectively.

I have already (p. 325) contrasted the effect of early and late burning on thicket and sapling growth. The following quotation is from a paper of mine, read in 1917 and published a year later, and written with no thought of tsetses in my mind.

"The fact is," I wrote (S.A. Journal Sc., June 1918, p. 16), "that land from which fire is excluded tends to go back to dense bush. Even the more open grass-veld here is full of stumps that seldom get further than a one season's shoot. The very fires that have rendered their existence on that ground possible, by driving the [primary] forest off it, keep them from growing up until, some year, a poor burn, it may be, or no burn, allows of a second season's growth being superadded to the first and gives a more fire-resisting bark to the latter. . . . Keep the fire from such a piece of ground—or burn too soon—for several years, and these shoots grow up and eventually in places become so dense as to reduce the grass and the severity of the fires and to allow semi-forest types as *Markhamia lanata* and *Albizzia chirindensis* to spring up amongst them, as I shall describe below, and eventually to replace them. The result [even] when this occurs so far from high forest as not to obtain seeds from it, is a form of dense thicket." On my own land *Uapaca-Brachystegia* areas burned regularly and more or less late have failed to develop appreciable undergrowth, while areas which, for winter grazing, have been burned irregularly and early, have developed it (Pl. xvii, fig. 2). The latter areas, which were clean-stemmed when I came here, would now carry *G. brevipalpis*; the former would not. Elsewhere in the irregularly burnt area new coppice wooding has sprung up in open ground from long suppressed underground stumps and roots and could already shelter *pallidipes*.

The converse statement—that late fires will destroy already existent growth—is true also. It is particularly true of a late fire following a year in which burning was omitted; and I have sometimes been much struck—the last instance was late in 1917—by the large size of the pyrophytic saplings that such a fire has killed down. On occasions even large pyrophytic trees are definitely killed by it, at any rate in such a season as 1913. Of the effect on primary-type thickets I have given an instance on p. 325 and have seen further instances myself.

With regard to the statement that late burning was a practice under the Zulu regime, I can say from personal observation that there was less wooding, and less undergrowth under existing wooding, in the Northern Mossurise district even when I lived and travelled in it from eighteen to nineteen years ago than there is now after a further period of unregulated burning. It is likely that this probable result of their late burnings contributed much to the Zulus' success, particularly of late, in

the margins of the "Oblong," and it is unfortunate that such fires should necessarily have ceased at the very moment when whole districts of native gardens were abandoned to grow up into coppice growth.

The effect on reproduction of burning at a time when a large proportion of the trees are in flower must also not be overlooked. I wrote on 5th December 1906 on examining a late "burn" between Chibabava and Arucate and observing that the flower crop generally had been destroyed, "it will be interesting to note to what extent this late burning will effect the seeding, and consequent replacement of dead individuals." There can be little doubt that it will affect it considerably in the lower types of wooding.

Late burning is no emergency measure against fly. In some areas especially, where the grass is already well reduced, its full effects may take long to show. Again, its abandonment will mean the return of the old conditions, for the underground stumps and roots of pyrophytes are extraordinarily tenacious of life. It must be regarded as a piece of administrative policy and be kept up annually. That its adoption is necessary I am quite convinced, if only for the reason that the country generally is at present reverting more and more to wooding and becoming increasingly fitted for tsetse, even in those areas in which the cover has hitherto been sparse and light. The recommendation of the measure, in face of its having to be kept up indefinitely, must be that the fires take place in any case and that the annual cost of regulating them will be trivial. The latter may even be met by the fines imposed on unauthorised burners, and the actual burning, being done at a signal by the kraal natives themselves, will cost nothing.

Apart from the prophylactic value of the measure just mentioned, its effect, grass conditions being equal (which they are not), should show first and chiefly in relation to *G. brevipalpis* and (in the area in which this fly depends mainly on coppice) *pallidipes*. It will not affect the grown pyrophytic trees in any wholesale manner (unless in a very exceptional season or unless they are weakened by ring-barking). Its effect in relation to *morsitans* might even be regarded as problematical, for that fly and *pallidipes* in the same wooding appear to be independent of undergrowth. The systematic burning back of smallish growth will assuredly tell as the established trees pass maturity and eventually go, with nothing to replace them, but the time involved will be long.

The objections that may occur should be discussed. One is that the loss of the wooding at springs may dry these up. Many of the springs rise already in open vleis, and wooding on damp ground (including big *Khaya* and *Adina*) is in any case not easy to destroy by burning, except occasionally in such a season as 1913. But better an occasional spring lost than a continuance of the tsetse; and the Zulu clearings, sufficient to remove the fly, do not seem to have caused any shortage of water. At worst, occasional lost spring-heads could be allowed to revert to wooding after the tsetse had been eliminated. The exposure of the ground to wash by burning shortly before the rains is not an effective objection, as it has been our experience here that the growth of spring-burned grass rapidly overtakes that of winter-burned grass, which itself affords little protection to the soil in October. Loss of, or damage to, the secondary wooding generally—unless of the very finest *Albizzia-Milletia-Pterocarpus* monsoon types—need not be regretted, for reasons which I have stated

in the paper from which I have already quoted. It comprises types that are relatively useless from every point of view. As for rainfall, the merits of wooding in bringing about this kind of condensation are in dispute, and at best only the big-wooding area of the Lusitu would need consideration ; but all local evidence goes to show that it is the mountains, not the wooding, that perform this service for us here. The objection in any case is applicable to any clearing measures.

Another difficulty is administrative. Even on the British side of the border, where unauthorised fires are forbidden by legislation, such fires still take place. This will happen also here, but the local set-backs involved will weigh lightly in the balance against the benefit that should accrue from the general success. The penalty for unauthorised burning should be severe, and even if it should be necessary to employ a few extra police-boys for four months in the year, the measure would be a very cheap one. There should be no discontent over it amongst the natives, as late burning represents their own old custom, and, whatever their infringements, they still speak of it as the correct method. Dr. Lawrence, speaking of the fact that native huts and granaries must have the grass round them burned at an early date to protect them against the grass fires, has suggested that it will be more difficult to protect against late fires, and that it will also be difficult, when one of the guard fires gets away, to discriminate between real accidents and pretended ones. It seems to me that the real accidents and cases of hardship will be reduced to a minimum—along with the carelessness or lack of adequate hoeing preparation that produce most of them—by a refusal to excuse them. The natives adapted themselves successfully to the late burning of the Zulu regime and even now have sometimes to meet late, fierce fires, as they had to in some of Gwenzi's heavy grass-jungle country in 1918. Naturally they would receive ample warning.

Another difficulty that has been raised in conversation—but it is no difficulty at all—is that late burning is supposedly bad for the pasture. The excellent grasses left us here by the Zulus, who burned late and regularly, are a sufficient reply. It is true that continued burning checks the development of a " close sole " of still better grasses that otherwise follows on heavy stocking by cattle ; but if you stop proper burning before you stock, you lose your pasture altogether. The land goes to dense wooding, as it is now fast doing everywhere in Mossurise. Wholesale late burning is in any case not being recommended for country that is already carrying cattle.

Simultaneous burning off of the infested country—and more or less simultaneity would in any case result from postponement—would probably discommode the flies on the wing in a more direct fashion. It would banish the game for the time being, and in the case of *brevipalpis* in the " Oblong," it would probably force the fly either to take refuge in the ravine-type thickets which a course of late burnings should eventually destroy, or, in part at least, to perish. Its probable effect on *morsitans* seems more doubtful in view of this fly's relative independence of shade, but observations by Lamborn (Bull. Ent. Res. vii, p. 39) and others show that it is usual even for this fly to desert burnt areas.

Unemerged pupae would no doubt remain in any event to repopulate the area but Lloyd took a greater percentage of dead pupae from burnt areas than from unburnt ; and if I am right in my expectation that the heat of the October fires

will reach a considerably higher proportion of pupae than those of the earlier fires, the anticipated effect on the flies on the wing would be well worth obtaining also. Birds, again, as I have shown already, probably attack tsetses most when these are in numbers together, and the temporary clearing of the game from a large area will remove the agency that keeps the smaller tsetses scattered, while hunger and the black background should increase the flies activity and visibility.

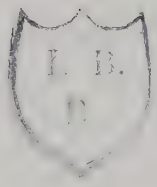
The one thing that has made me hesitate to recommend simultaneous burning is a slight doubt as to its exact effect on the insectivorous bird population itself. October burning in any case encroaches somewhat on their breeding season, but not to an important extent—that is, the early nesters that have had their nests destroyed have still plenty of time before them, and even in ordinary years an amazingly large proportion of them has to make a fresh start as the result of the depredations of enemies that are likely to be adversely affected by late burning. Again, a fire and the few days following it are feast days, for a very large proportion of the winged insect population escapes it and, being then more conspicuous against the universal blackening, is more readily detected by the birds, which may sometimes be seen searching the burnt ground in parties. The real point is whether the wholesale destruction everywhere of the insects' own food will so much reduce their numbers as to react adversely on the birds. I think that there will be no difficulty here at all, for in this district at that time of the year the response of the vegetation after burning is immediate and most rapid, and a burn gets repopulated with wonderful speed, the new brood of grasshoppers even showing colour adaption to the scorched surroundings ; but the effect of simultaneous burning on the insectivorous birds should be noted nevertheless.

In short, the effects of *simultaneous* burning, while very promising, have yet to be accurately observed ; but the good effects of *late* burning have actually been demonstrated.

I wish, therefore, to make it the one outstanding recommendation of this report that late burning—with, very frequently indeed, a year of no burning—should be given a trial over a considerable number of years ; also that, in the first season at any rate, an effort should be made to have the burning as simultaneous as possible over a large block. The rubber forests and finer Lusitu wooding generally could, if desired, be left out of the scheme. Early burning thereabouts, every year, will save them. It will also unfortunately spread both them and the fly. The fine timber there must be considered also ; and against the reduction of the cost of clearing which late fires might have effected by the time this section comes to be settled, must to some extent be placed their destruction of the surface humus. Elsewhere this is being destroyed in any case by the useless fires ; it may as well therefore be destroyed by useful ones. The very deciduous areas at the higher elevations need not necessarily be included either, but they are not sufficiently extensive to be worth excluding, especially as their wooding (for the most part of little value) will remain a great annual danger so long as any permanent fly survives below.

To give the measure a definite experimental value sample plots or areas in each type of wooding should be selected, described, charted and photographed. These, examined from time to time, would afford a measure of the success or failure of the experiment.

Primary "rain" forest; the large trees are African mahogany (*Khaya nyasica*). At suitable elevations this type of forest harbours *Glossina brevipalpis* in the dry season.


I. B.
P.

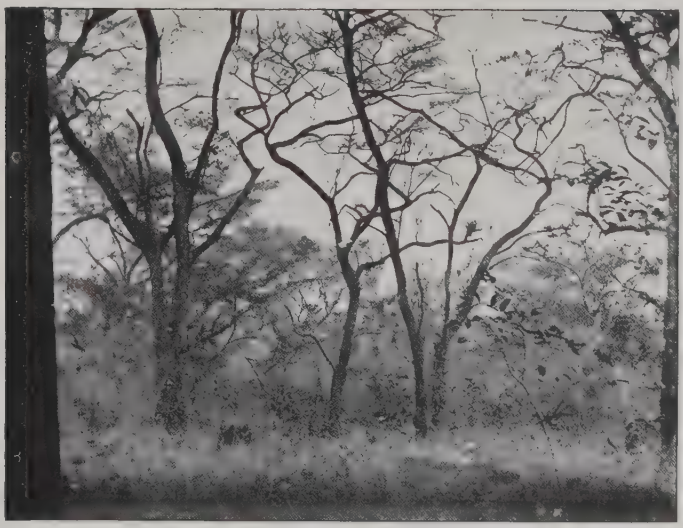


Fig. 1. Highly deciduous secondary forest on Mount Umtareni in August, with *Pterocarpus angolensis* and *Terminalia sericea*. Capable of sheltering *Glossina brevipalpis* and *G. pallidipes* in the wet but not in the dry season.

Fig. 2. Lowland bush-savannah on the basalt at the younger Gunye's, *Combretum* dominating; harbours the overflow of *G. morsitans* from the *Brachystegia* for much of the year.

A typical scene in the Madanda rubber forest. An *Erythroxylon-Landolphia* invasion of tree-savannah and savannah-forest, capable of harbouring *G. brevipalpis* and *G. pallidipes*.

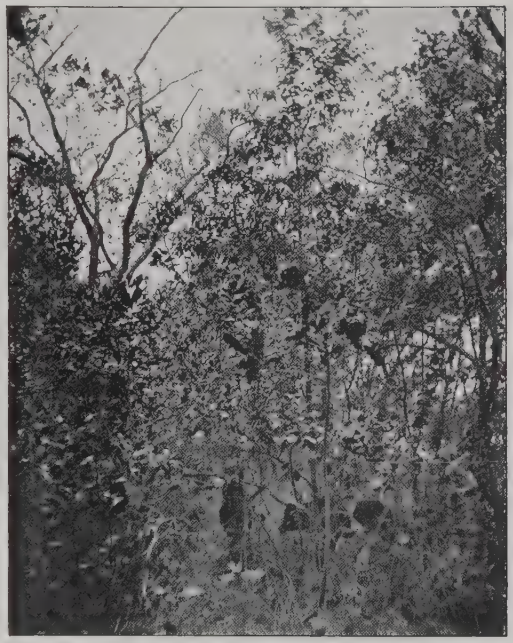


Fig. 1. In *Uapaca-Brachystegia* bush; lower shade-layer only, therefore no *G. brevipalpis* present.

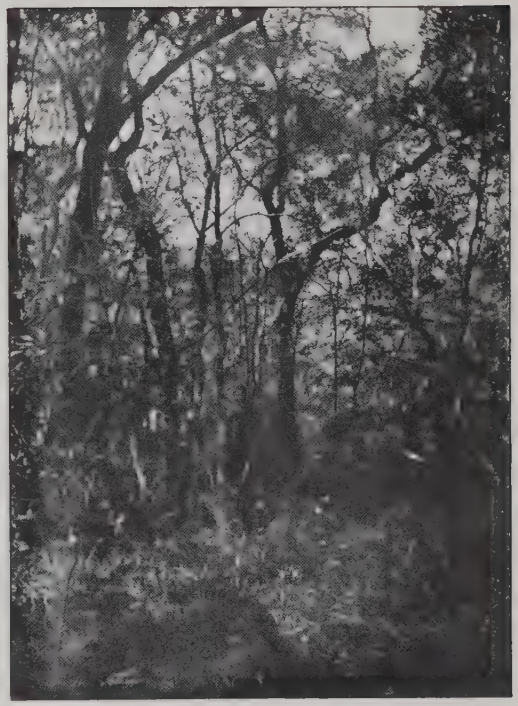


Fig. 2. In *Uapaca-Brachystegia* bush; two shade-layers, and *G. brevipalpis* present.

Fig 1. In *Uapaca-Brachystegia* bush; only an upper shade-layer, and therefore no *G. brevipalpis*.

Fig. 2. *Landolphia* wooding of the Lusitu rubber forest type; with a lower shade-layer of this high, very dense type *G. brevipalpis* was present even when the higher trees were leafless.

I. B.
E

Fig. 1. Nearly 100 puparia of *G. brevipalpis* were taken under this fallen *Piptadenia buchanani* at the spots indicated by the papers.

Fig. 2. A very typical breeding-place of *G. morsitans* under a long-fallen trunk of *Burkea africana*.

I. B.
E.

Fig. 1. Site of a male cluster of *G. morsitans*; the short grass was very green and luscious, and the flies occurred both on it and on the longer grass near.

Fig. 2. Experimental net and its furniture, as used for *G. brevipalpis* and *G. pallidipes*.

L. B.
E.

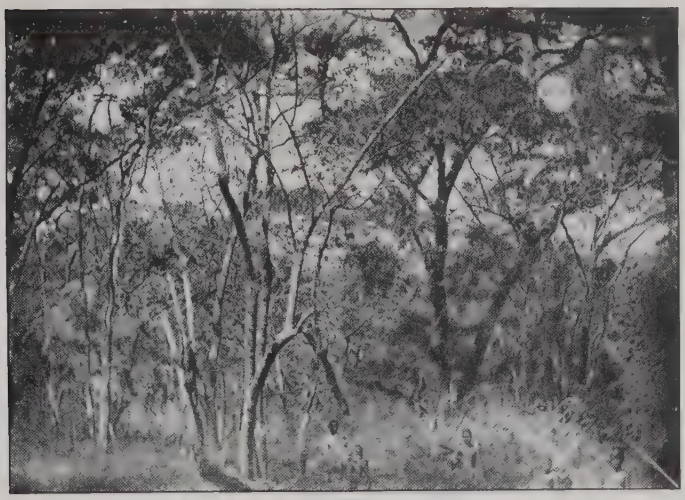


Fig. 1. Clearing experiment No. 1. Undergrowth uncleared; *G. brevipalpis* present in abundance.

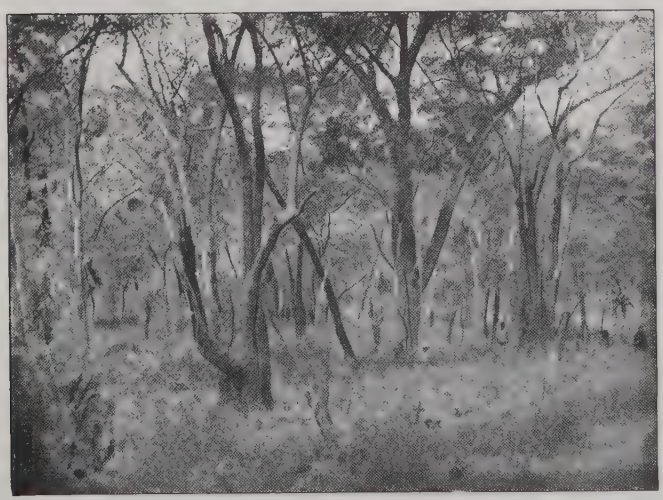


Fig. 2. The same spot with the undergrowth cleared; *G. brevipalpis* has entirely disappeared.

I. B.
E.

Fig. 1. Coppice type of secondary bush, strongly favoured by *G. pallidipes* west of the Sitatonga Hills. This bush has grown up in 12 years on deserted native gardens.

Fig. 2. A thicket on a piece of land belonging to the writer resulting from early and irregular burning for a good many years; it was previously clean-stemmed wooding.

I. B.
E.

Map to Illustrate REPORT ON A STUDY of the NORTH MOSSURISE TSETSE PROBLEM.

Chimanimani Massif (Peaks over 8000 feet.)

Mount Singwekwe or Pene, 6000 ft.

Haroni R.

Lusitu R.

Mafusi Rubber Forests

MAFUSI

MAKWIANA

THE "OBLONG"

MARONGA

UKOA

MTOBE

BUNGA

MUTANDA

GOGOYO

GUNYE

UMPOMBO

UDOMBE

USAMBAI

MUCHAMBA

INYAMSIZWA

CHIBUYE'

GUDZA

UMVUMO

JAMBI

Musapa R.

Mvumose R.

Fly reported particularly abundant here

Scattered patches of dense bush reported here

Buzi R.

Umbuazi R.

Chikombwe

Makwakwa (and elder Gunye)

Mt. Chingudo

Mafure-abati.. Secondary wood

Kanyezi vleis & fly centre

Kanyezi Gundoda

Mapapa vleis, etc.

Mangunde

Mutshukwana

Ndabila

Chibabava

To Arucate and Madanda forests.

Muyamgwanga R.

Matete & younger Gunye

Mutomapa Nhlome

Mapumpi Inyanatinde R.

Masande or Mahloka wood and vleis

Makanda R.

Kuboia

Inyabangwa Masahande

Mazenge R.

Mutsadzwa

Mowewa (dry July)

Stream with Khaya forest

Mtakazana

Kadzweyi R. Rapids

Gadoza

Inyajena

Cowardo Zulu Cattle (Uboi) kraal

Gowana (Low-lying and flattish with fairly numerous small hills)

Mabuzan

Chiodzoza

Mbhanga

Mabiya

Mt. Wenangazi

Mt. Mubvarutwa

Matekwi (kraal)

Matekwi R.

Mshwiana's Makubun s.f.p.

Mt. Mubogodo

Vleis

Mudinywa

Musore

Makoname R.

Matantore

Chiredza

Inyamadzi

Mt. Umtareni

Chizi R.

Buzi R.

Mutsadzwa

Inyamaruru R.

The Crag of Ilamba

Dengedza f.p.

Spur-fishers

Pole & reel

Brick kraaler

Isejere f.p.

Mudzi-bowa

Maku Nguwha f.p.

GWENZI (The "Jihu")

Zulu cattle-keeping under Gungunyana

Mabudu

Marika R.

Chinyika R.

Dense thicket

Mt. Singuno

Khayas

Some Pachystegia

Gungunyana's capital

CHIKWEKWETE

CHIOMO etc.

Alleged Fly.

Zulu cattle formerly very great numbers

Mswirizwi (Mossurise) R.

Hot spring

Diplorhynchus (Matawa) common—in parts dominant—from Singuno's S. foot to Chimbiya.

Inyamadzi R.

Inyamamba R.

Zona R.

Kurumadzi R.

Chikambwe R.

Inyamowana R.

Chipepeta R.

Inyamkuwha R.

Ndagala R.

Mpengo (Mt. & f.p.)

Maruma (Mt. & f.p.)

Mutashi f.p.

Tutunye f.p.

Selengwane s.f.

Mabuzan Gundoka

Dynare Zonedzan

Kambadzi R.

Sibizwa Chibede

Matekwi R.

Mabuzi R.

Sitaponga R.

Gogoyo Hills

Chambwa R.

Mucharnbwa R.

Puizise R.

Mtobe

Mavudzi R.

Mafusi Makuben s.f.p.

Younger Mafusi

Detached woods outliers of rubber forests.

Camp

Bindet hereabouts

Maheza

Chikwiri R.

Mafusi R.

Umtshanedzi R.

Umtshanedzi

Mabuzan

Chiodzoza

Mbhanga

Mabiya

Mt. Mubvarutwa

Matekwi (kraal)

Mt. Wenangazi

Dangara R.

Muchambe

Mtakazana

Kadzweyi R.

Rapids

Gadoza

Inyajena

Cowardo Zulu Cattle (Uboi) kraal

Gowana

(Low-lying and flattish with fairly numerous small hills)

The more prominent points of a somewhat broken piece of country

Buzi R.

Umtshanedzi R.

Umtsefu R.

Mashili

Chimbiya

Myangezi R.

Muzala R.

Inyamkuwha R.

Chipepeta R.

Ndagala R.

Mswirizwi (Mossurise) R.

Inyamamba R.

Zona R.

Kurumadzi R.

Chikambwe R.

Inyamowana R.

Marika R.

Chinyika R.

Mucharnbwa R.

Puizise R.

Mavudzi R.

Mafusi R.

Sitaponga R.

Gogoyo Hills

Chambwa R.

Dangara R.

Makoname R.

Inyamadzi R.

Chizi R.

Buzi R.

Lusitu R.

Musapa R.

Mvumose R.

Umvumo

Buzi R.

Nummulitic Limestone

47·15 m. To "Buzi Colonial" Station whence sailing boat to Beira

Chironda

From Chironda for a dozen miles eastwards, on limestone, a larger proportion of dense close bush and scattered thickets (largely Pavetta salicina). Further east more open, but with bigger trees (still open) near river. Approaching Inyamita (195 m. from Buzi Colonial) more open still, scattered palms and Combretum.

11·55 m.

6·25 m.

8 m.

10 1 m.

13 m.

12·8 miles.

13·45 miles.

6·75 m.

9·5 m.

Bush on river (Chibabava) a park-like arrangement of large (Necanopsis, Philadelphus, Kirkia, Trichilia sp. etc.) Otherwise by no baobabs. Lonchocarpus woodland, Albizzia Piliostigma Tamarindus, Albizzia Acacia spp. and shrubs as Pavonia Grewia Acacia caffra Holarrhena caffra

Peaks as seen, clumps of thick bush, small Bauhinia trees mostly upon

Scattered clumps of thick bush, small Bauhinia trees mostly upon

Open bush, sparse or large trees, bushy undu-lations

Bigger bushy streams

Fan palms — Hyphaene — become common from here eastward, throughout.

The Umpoza (Combretum nr. apiculatum) very common. (Combretum from the Inyamkuwha southwards and Pelopogan) Mostly Isoberlinia association with low Thuria on basalt. Thuria occurs.

At Umtsefu chiefly Acacia caffra; Bauhinia reticulata, Albizzia hypoleuca Kigelia and Entada; not dangerous all the year

Soil Chimbiya to Inyajena largely brackish alluvial much cracked; frequent outcrops of water-worn stones Flat to slightly undu-lating Open to bush, undu-lations sparse or large or stunted never dense Better or trees at streams dry or otherwise.

Explanation.

Mainly basalt; wooding mostly sparse and low, bush-savannah, "Umpoza" dominating; fly pallidipes and morsitans, apparently chiefly as overflow from the salmon and (pallidipes) dark-green areas.

Mainly granite-gneiss; rather poor but ± continuous Brachystegia savannah forest with many vleis. Fly pallidipes and morsitans and, in places, a few brevipalpis.

A great sedimentary exposure—sandstone, shale quartzite and good Brachystegia—Uapaca savannah forest, continuous brevipalpis everywhere in the thickets, pallidipes in smaller numbers.

Mainly dolerite; wooding for the most part highly deciduous; permanent fly absent.

Mainly dolerite; broken wooding chiefly of the various dense-secondary types, especially fern-entwined. In the main deciduous, but late in the season, and the permanent fly (pallidipes and brevipalpis) more localised then than in the rose and dark-green areas, Brachystegia (and fly) on scattered sedimentary exposures, commonest between Puizise and Umtshanedzi.

Mainly dolerite and schists. Wooding contains an unusually large element of the primary (chiefly "ravine") and the finer secondary "monsoon" types: Khaya, Piptadenia, Albizzia, Milletia, Pteleopsis. Much Landolphia kirkii in North. Brevipalpis apparently abundant throughout, pallidipes present.

Route of main expedition. Route of two native expeditions.

Buzi route: shown very approximately, but distances (cyclometer and timing) probably nearly correct. The notes appended to it were made in 1906-7 and the wooding may have increased since.

Four main working camps. s.f. = secondary forest. f.p. = primary forest-patch T. = G. austeni vleis.

Anglo-Portuguese frontier and numbered beacons. Buffalo passage areas, routes and approaches. U. = Umgazaza's kraal. Ma. = Mapondo's. N. = New kraal below Chipungambira forest. F. = Ferry and kraals of Siyaghiya and Shilling.

Flies taken furthest west. From "1" north-eastwards brevipalpis was present almost continuously in numbers. "2" = a fly taken by Mr. Jack. "3" by Dr. Lawrence, August. "4" and "5" flies (pallidipes) seen on June 13th, 1918. "6" a combined attack by pallidipes and brevipalpis. 7 = brevipalpis continuous in thickets, from here to Buzi. "8" brevipalpis, do. ± "9" Jack's high-elevation pallidipes, August, 1917. "10" brevipalpis dry season limit here. "11" Wilder and Lawrence's Isetse, 1900. "12" and "13" most westerly and southerly morsitans, respectively. "B" = highest elevation brevipalpis, 3000 ft. or somewhat over. More westerly pallidipes than Jack's were taken on the Inyamadzi.

Eastern boundary of cattle-keeping under Umzila and Gungunyana; also, roughly, the line of maximum clearing in the Puizise-Mtshanedzi area.

Recent boundary of cattle-keeping now pushed back to the old boundary of the pre-Umzila period.

Some definite Zulu failures. Recent nagana outbreaks.

Note. The contouring is diagrammatic and gives merely a fairly correct general idea of the presence of hill-masses and their relative importance. The frontier is taken from the official Rhodesian map and the portions (taken by compass from frontier beacons) of the Sitatongas, higher points of the oblong, Umtarene and the Spungabera details are probably fairly correct also the windings of the Buzi from Itamba northwards and, in a more general way, the course of the Umtshanedzi and the entries of the tributaries and the positions of some Kafir kraals and river-crossings.

View from here (Nov., 1906), showed low country to S.E. covered densely with trees, stated by natives to constitute "Magusha," or dense forest; that along Buzi route was seen to be very sparse.

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MOSQUITOS COLLECTED IN PALESTINE AND ADJACENT TERRITORIES.

By Capt. P. J. Barraud, F.Z.S., F.E.S.

These notes include observations made on the mosquito fauna of Palestine, for the period July 1919 to August 1920.

In September and October 1919 a somewhat rapid tour was made through Syria and Cilicia, while from time to time short visits have been made to Egypt.

The climate of this part of the Mediterranean region is divided into wet and dry seasons, the latter usually prevailing from May to October, inclusive. In the northern parts of Syria and Cilicia the dry season is of rather shorter duration. From November to April there is a heavy rainfall over the larger part of Palestine and the countries to the north, but in the lower Jordan Valley, and in the deserts of the south, the amount is much less. The winter is mild, especially along the coastal belt and in the lower Jordan region, the thermometer seldom falling to freezing point. In some seasons there may, however, be a considerable snowfall in the mountains.

With the advent of summer, the country quickly becomes arid. Rivers and streams are few and insignificant, and the inhabitants of the towns and villages are obliged to rely for the most part upon wells or supplies of rain-water collected in catchment tanks. In certain parts of the country there are, however, perennial streams, and in some cases these form extensive marshy tracts, affording breeding grounds for mosquitos during the greater part of the year. Irrigation is practised throughout the dry season in districts where the supply of water is sufficient from springs or surface wells.

The summer weather in the Jordan Valley can only be described as tropical. Along the coastal plain there is usually a sea breeze, but when this fails, the moist heat is often trying. The higher parts of the mountain ranges enjoy a succession of hot sunny days, tempered by cool breezes, with a greater fall in the temperature at night. The maritime plain, consisting for the most part of rich grain lands, orange groves and olive yards, varies in width from a narrow strip where the mountains approach the sea, to many miles where they recede.

The mountains of Judea and the Galilean hills, rising here and there to 3,000 feet, form the backbone of Palestine proper. They consist chiefly of barren limestone. To the eastward they descend in tumbled masses to the Jordan Valley, a unique and stupendous crack in the earth's crust, sinking to 1,200 feet below sea-level. On the far side the mountains of Moab divide the valley from the tablelands of Bashan and the Arabian desert.

The larger part of Palestine, especially the central and northern regions, Syria, and Cilicia are malarious. A fairly high percentage of the native population in some of the towns and villages has been found to be infected, and well known malaria-carrying species of *Anopheles* abound. The duration of the malaria season roughly corresponds to that of the dry period, from May to November.

In early summer the Bedouins, with their flocks, descend to the plains in search of pasture and water. From their habits it has been assumed by some authorities that the majority of these people are malaria-carriers, and in their wanderings assist in the spread of the disease, but I am not aware that this opinion is based upon any extensive investigations. It is possible that these people derive a certain protection from the fact that they are usually accompanied by numbers of the larger domestic animals, horses, donkeys, camels and cattle. I have observed that frequently some of these are stabled under one end of the curiously shaped bivouac tents used by the Bedouins. These conditions appeared to be favourable for the feeding and sheltering of Anophelines.

Although I was unable to prove that Anopheline mosquitos prefer feeding upon animals rather than man in this part of the world, I have noticed, when searching camps, that they are usually to be found in larger numbers in tents pitched near horse or mule lines. In the towns and villages the number of large domestic animals would not be sufficient to supply food for the abundant *Anopheles*, and in these places, no doubt, they mostly subsist upon the blood of human beings.

One of the most abundant domestic mosquitos of the country is *Anopheles bifurcatus*. I have seen it breeding in countless thousands in the basement rain-water cisterns, which are to be found almost universally beneath and around private houses. As this stored water often represents the sole supply for the inhabitants during the summer, anti-malarial work is difficult, and opposition is sometimes met with.

In Jerusalem there are upwards of 4,000 basement cisterns, besides an extensive system of ancient drains and sewers, many of which have become blocked by subsidences. Some of these cisterns are of considerable size, having a rain-collecting platform as large as a tennis court, with a correspondingly large surface of water beneath. They are from 15 to 20 feet deep, and usually have only one opening about 2 feet square, so that a satisfactory examination is hardly possible. Even where a lid or cover has been made mosquito-proof, and a pump fitted to draw up the water, there is always an opening through which the rain enters. Mosquitos find their way in and out through this. Large surface wells protected by masonry are another frequent source of trouble. One of the most important medical problems with which the new Administration has to deal is the provision of an adequate piped water supply to all the towns, and the abolition of basement cisterns, surface wells and catchment tanks.

In Egypt, where the incidence of malaria is much less, the three chief Anopheline carriers of Palestine, viz. *A. maculipennis* var., *A. bifurcatus* and *A. superpictus*, are practically unknown. *A. multicolor* is there considered to be the principal carrier. It is common in the Canal zone, and especially abundant in the oases. It is in the last-named places that malaria is most prevalent. Here again the population is largely a nomadic one, tending to spread the disease from place to place. It is interesting to note that all the species of *Anopheles* so far found in Egypt occur also in Palestine, in spite of a wide strip of waterless desert separating the two countries. On the other hand, there are four or five species in Palestine which are absent from Egypt.

Anopheles maculipennis, Mg., var.

This is generally distributed over Palestine, Syria and Cilicia, but although recorded from Egypt by earlier workers, has not been found there in recent years.

The adult has the wings less distinctly spotted, especially in the male, than the European form,* some specimens being unspotted. The resting position on a vertical surface is rather flat, this being more noticeable in the male. Gorged females resting on a tent roof hang down in the usual Anopheline position.

Major S. R. Christophers discovered this faintly spotted form in Mesopotamia and wrote to me in regard to it, mentioning that the egg differs from that of the typical *A. maculipennis* (figured by Nuttall and Shipley in Journal of Hygiene, i, pl. ii, figs. 1 and 2) in that it has a frill of air cells all round the edge, instead of one pair of lateral floats. This observation I have been able to confirm in the eggs of Palestine specimens. The full-grown larva and the adult do not, however, appear to differ structurally from the type, and it remains to be seen whether the variety here referred to should be regarded as a distinct species.

The larvae are usually to be found in natural water both fresh and brackish. The adults have been found in very large numbers in tents and huts in camps, in various parts of the country, and often cause a heavy incidence of malaria. They will sometimes travel a considerable distance from the breeding-grounds, especially when emerging in large numbers. On 27th September 1919 I visited a camp at Toprak Kali, Cilicia, which was situated on a hill 500 feet high, and one and a half miles from the nearest water. In the earlier part of the year this site had been considered safe from a malaria point of view. The tents were, however, found to be heavily infested with both *A. maculipennis* var. and *A. superpictus*. Very similar observations were made on 1st October at a camp in the valley of the Ak river, near Marash, Northern Syria, from which large numbers of cases of malaria were being evacuated. In the first tent examined (square Indian pattern) there were over 300 *Anopheles* in one corner, while a patient lying beneath had 70 inside his mosquito net. These were nearly all *A. maculipennis* var., with a few *A. superpictus*; some of the former were noticed to be biting in the daytime. Although the river passed within a few hundred yards, very few larvae, or likely breeding-places, could be found. In marshy ground and rice fields at about one and a quarter miles distance, however, the larvae were in abundance.

Breeding commences in April and May, according to the season, in the marshy areas along the coastal belt of Palestine. In the Jordan Valley, at depressions below sea-level, it probably begins earlier. During the first part of May 1920, I collected large numbers of larvae and pupae in a shallow brackish marsh lying amongst the sandhills, east of Haifa, and near the mouth of the Kishon river. Larvae of several other species, viz. *A. multicolor*, *A. hyrcanus*, *A. mauritianus*, *Culex univittatus* and *C. tipuliformis*, were found at the same time. By the end of May larvae were much less numerous, the day temperature of the water in the marsh having then risen to 88–90°F.

* The North European form has not been found in Palestine, but the two forms occur together in Macedonia.

Adults of *A. maculipennis* var. were found in camps on the sands near the Kishon, and a few from time to time in camps above Haifa town at 300 feet ; also in the lower western part of the town, at least one and a half miles from the nearest breeding place, as far as I could discover. Larvae were never found within the town limits, either in covered or uncovered collections of water.

At the end of April larvae began to appear in an area flooded by late rains, north of Acre town, in the neighbourhood of a battalion camp. This area soon became dry, but in the meantime large numbers of *A. maculipennis* var. had hatched out, and an outbreak of malaria occurred, lasting several months. The first primary case of benign tertian was reported on 28th May and of malignant tertian on 27th June.

The species occurs from 1,200 feet below sea-level to 2,300 feet above. My collection includes specimens from the following places :—

Palestine : Sarona (near Jaffa) ; Zummarin ; Athlit ; Haifa ; Acre ; El Afule ; Jenin ; Tabgha (north of Tiberias), along the course of the Jordan from the Sea of Galilee to near the Dead Sea. Syria : Damascus ; Homs ; River Ak Valley (near Marash). Cilicia : Missis ; Jihan ; Toprak Kali.

Anopheles bifurcatus, L.

As mentioned previously, this is the most abundant domestic Anopheline mosquito of Palestine and Syria, breeding almost exclusively in basement rain-water cisterns and covered surface wells. I did not discover the larvae in any natural open water in Palestine, but at Beirut (Syria) larvae and pupae were taken from a small gently flowing stream containing much vegetation and over-grown with bushes. It appears to be essentially a cool-water species. The temperature of the water in basement cisterns in a coastal town, such as Haifa, varies between about 58°F. in winter and 78°F. in summer. During the spring and early summer, when breeding is most active, the water was found to remain at about 62°F. Larvae may be found throughout the year in their favourite haunts, but feed up more slowly in winter than during the warmer months. The majority of larvae must pass their whole existence in semi-darkness, the sun's rays seldom penetrating to these deep cisterns.

Examinations were made at Haifa in November, before the autumn rains, when many of the cisterns were dry or contained very little water. In most cases they were clean, with very little, if any, debris upon the floor. In others, which had probably not been cleaned out for some years, the walls had become green, and there was a thicker floor deposit. Further investigations in January, after about six weeks of heavy rains, revealed the presence of very large numbers of adults. Collections were made of individuals resting on the walls, within reach of the opening. At first I was under the impression that they were all females, but while carrying out a series of fumigation experiments, it was found that in cases where all the mosquitos had not been killed by the fumes, most of the survivors were males. These were resting or flying about near the openings when the cisterns were examined. On several occasions in January I was bitten by females disturbed from cisterns.

Examinations were continued in April in parts of Haifa not previously visited. Larvae were found to be present in nearly every case, together with adults. Usually some larvae were obtained in the first bucket of water drawn. After that it was

difficult to secure many more, even though in one case twenty buckets of water were examined in succession. When disturbed they evidently move away from the vicinity of the opening. As far as I could judge, from a number of observations made, the larvae of *A. bifurcatus* living in these situations are chiefly surface feeders, existing upon debris which may be washed in by the rains.

I successfully reared adults from the egg by keeping the larvae in a bowl of clean water and feeding them upon a diet of chopped flies. A few young larvae found on 18th November fed up slowly in the same way, living for about two months before pupating. The adults prefer cool and dark places in which to rest during the day, and were not found in any abundance in houses or tents.

Except for occasional individuals the species is absent from Egypt. Specimens were obtained in the following localities from sea-level to about 3,000 feet :—

Palestine : Jerusalem ; Bethlehem ; Jaffa ; Haifa ; Acre ; Nazareth. Syria : Baalbek ; Zahle ; Beirut.

Anopheles algeriensis, Theo.

I think this must be the species referred to by previous workers in Palestine as *A. fragilis*, Theo., or *A. aitkeni*, James. It does not appear to be very general, and I have no records for Egypt or Cilicia.

One female was captured on 3rd December 1919 in a tent pitched in the marshes east of Acre ; this had recently sucked blood. On 11th and 12th August 1920 it was found in numbers at Wadi Selhab, a marshy tract about three miles south of Jenin on the Nablus road and over twenty miles from the coast. The females were biting freely at sunset, and some fifty specimens were caught in half an hour. The only other mosquitos seen at the same time were *A. hyrcanus* and *Culex pipiens* (one).

It would appear to breed chiefly in the larger marshes, away from human habitations, like *A. hyrcanus*, and is therefore probably not a frequent carrier of malaria. It has been found in the marshy areas of the Auja valley, between Mulebbis and Jaffa.

A few specimens were bred from larvae found in a small marsh on the outskirts of Beirut, in September 1919.

Anopheles hyrcanus, Pall. (*sinensis*, Wied. ; *pseudopictus*, Grassi).

As mentioned above, this species breeds chiefly in the larger marshes and is to be found along the coastal belt of Palestine, at least as far north as Acre. It also occurs in suitable localities inland. I think there is no doubt that it is to be found in Syria and northwards, but I did not meet with it. I believe that up to the present it has not been found in Egypt.

The adults may be found nearly all the year round, but in larger numbers in winter and spring.

Palestine : Marshes in the Auja Valley, near Mulebbis ; Athlit ; the Kishon Plain, from Haifa to Acre ; Wadi Selhab, near Jenin.

Anopheles mauritianus, Grandpré.

This is one of the *Anopheles* which is to be found regularly in Palestine and Egypt. In the former country it breeds in much the same environment as *A. hyrcanus*, viz. the swamps of the Auja and Kishon rivers. I have not met with it inland, or in Syria. In Egypt it is found chiefly in the lake margins and swamps of the Delta.

The adults appear to be most common in the early part of the year.

Anopheles superpictus, Grassi (*palestinensis*, Theo. ; *nursei*, Theo.).

Generally distributed over Palestine and Syria, and met with in Cilicia. The larvae are usually found in natural water, and prefer clear pools, near springs of fresh water.

The adults are no doubt responsible for a great deal of the prevailing malaria in country districts, as distinct from towns. My collection includes specimens from the following localities, from 1,100 feet below sea-level to about 3,000 feet above :—

Palestine : Sarona (near Jaffa) ; Ludd, Latron, Ram Alla (near Jerusalem) ; along the course of the river Auja from Rasel Ain to Mulebbis ; Beisan ; Tabgha ; at many places along the Jordan from Beirut Yakub bridge, on the Upper Jordan, down to Ghoranyieh (near the Dead Sea). Syria : Ak river, near Marash ; Zahle, Lebanon Mountains. Cilicia : Bozanti ; Toprak Kali, Taurus Mountains.

Anopheles culicifacies, Giles, var. **sergenti,** Theo.

This mosquito was not discovered until the end of my stay, and I think it is probably often overlooked amongst numbers of the preceding. A few females were found in tents at Tabgha, on 15th August 1920. Previously a few specimens were bred from larvae found in pools along the Nazareth road, near Haifa.

Anopheles multicolor, Camb. (*chaudoyei*, Theo.).

This insect has been previously known to workers in Palestine as *A. turkhudi*, Liston. It is now found to be distinct from the Indian species.

The larvae are often found in large numbers in brackish marshes along the coastal plain of Palestine, in late autumn, spring and early summer. It is not, however, confined to the coast, and occurs in salty pools and streams in the Jordan Valley. As mentioned on a previous page, it is considered to be the chief malaria-carrier in Egypt, where it has a wide distribution.

Anopheles pharoensis, Theo.

Although abundant in some parts of Egypt, it is regarded as a doubtful carrier of malaria. In October 1919 I found it commonly at Kantara, on both sides of the Canal, and also in the northern suburbs of Cairo. It is very rare in Palestine, and I obtained only one female. This was found at Tabgha, north of Tiberias, on 15th August 1920. I have no records for Syria.

Stegomyia fasciata, F.

This is exclusively a domestic species, found in most parts of Egypt, Palestine and Syria, at least as far north and east as Aleppo.

Larvae were found in water receptacles of all descriptions, including flower-vases in a sitting-room, fire-buckets containing clean water, and a disused boiler in a kitchen.

The adults are most troublesome in the hot season, and are suspected of being carriers of the organism causing "Aleppo sores" and "Jericho boils." Some of the Palestine specimens are very beautiful, having the dorsal surface of the abdomen almost completely covered with silvery scales.

PALESTINE: Jaffa; Jerusalem; Haifa; Jenin; Tiberias. SYRIA: Beirut; Damascus; Aleppo.

Ochlerotatus caspius, Pall. (*dorsalis*, Theo., *nec* Mg.)

A very abundant and widely distributed species in Egypt, but so far as my observations go, it is not so common in Palestine.

The larvae prefer brackish water.

A few adults were found at Haifa in June 1919.

The night of 31st March 1920 was spent at Jisr el Damie, Jordan Valley. During the evening we were attacked by clouds of mosquitos, but owing to an unfortunate accident to my supply of tubes, I was unable to bring back a large number of specimens. A few of this species were secured, together with *O. detritus*, *Theobaldia annulata* var., and *Anopheles superpictus*.

Ochlerotatus mariae, Serg.

One of the few mosquitos to be found breeding in sea-water. Large numbers of ova, larvae and pupae were found in pools above high water mark on the rocks at Athlit, Palestine, in August 1920. In June and July 1919 larvae were abundant in similar situations along the coast to the south-west of Beirut, Syria. The pools become very salt owing to evaporation, and the temperature of the water, by exposure to the sun, is usually well over 90° F. for the greater part of the day.

The adults bite freely in the daytime, and cause much annoyance to people bathing from the shore.

Ochlerotatus detritus, Hal. (*salinus*, Fic.).

A very abundant and troublesome species in parts of Palestine during the wet season and spring.

The larvae are found chiefly in brackish water, near the coast, but I also found them in large numbers in the Jordan valley at the end of March 1920, at 1,000 feet below sea-level.

PALESTINE: Zummarin; Haifa; Acre; Jisr el Damie, Jordan.

Culex pipiens, L.

Abundant and widely distributed in Egypt, Palestine and Syria, and found as a rule near human dwellings. The species occurs from sea-level to 4,500 feet.

The larvae differ in some respects from Western European and Mesopotamian specimens, and appear to represent a distinct race. No differences can, however, be discovered in the adults. Larvae collected in Jerusalem, Haifa and Baalbek (Syria), are very uniform in structure and size and show the following obvious differences from typical specimens : Full-grown larva smaller, with distinctly shorter siphon ; slightly smaller average number of pecten teeth ; antennae light, instead of dark. In one case larvae were found living in a well in which the water-level was 85 feet below the ground.

The adults exhibit a certain amount of variation in the abdominal banding, in some specimens the white bands being incomplete dorsally.

[**Culex fatigans,** Wied.]

Although this mosquito was recorded from Egypt by several of the earlier workers, it does not seem to be found there. An examination of the genitalia of all males in the collection of the Egyptian Ministry of Agriculture has proved them to be *C. pipiens.* I have been unable to find the species in Palestine or Syria.

Culex laticinctus, Edw.

The larvae may sometimes be found in very large numbers in covered surface wells, tanks, and similar situations in Palestine.

The adults have been observed in quantities in tents in camps. In Egypt it is found commonly at Alexandria.

Palestine : Jerusalem ; Wadi Hamish ; Haifa. Syria : Baalbek.

Culex univittatus, Theo.

Distributed from Egypt to Syria, but never in any great abundance. The larvae live in marshes and stream pools, generally away from dwellings. One is liable to overlook them, as, when disturbed, they immediately leave the surface, returning for only a second or two at long intervals.

There still seems to be some confusion regarding the larval characteristics. My specimens disagree in almost every particular with the description and figure given in Bull. Ent. Res. x, p. 69, 1919 ; neither do they fit in with the synoptic table given in the same journal vol. iii, p. 381, Dec. 1912. I have handed some of my material to Mr. F. W. Edwards, who has kindly offered to go into the matter, and publish the results in a future paper.

Palestine : Wadi Hamish ; Sarona ; Haifa. Syria : Beirut.

Culex tipuliformis, Theo.

Found in similar situations to the preceding. It has not, so far as I am aware, been recorded from Egypt under this name, but there is a specimen from the Fayum in the British Museum collection.

Palestine : El Afule ; Acre ; Haifa. Syria : Damascus.

Culex hortensis, Fic.

Although I was on the look out for this species in Palestine, very few were found. Some females were taken at Haifa in May 1920. No doubt it is common enough in some parts of the country. At Damascus, in July 1919, larvae of this and of *C. tipuliformis* were dipped from the same pool. It appears to be absent from Egypt.

Culex mimeticus, Noé.

Not uncommon in suitable localities in Palestine, Syria and Cilicia, but absent from Egypt. The larvae have been found associated with those of *A. superpictus*.

Palestine: Wadi Hamish. Syria: Beirut. Cilicia: Bozanti.

[**Culex modestus,** Fic.]

This was not met with, but is likely to occur, since it has been found in Macedonia and Egypt.

Theobaldia longiareolata, Macq.

One of the commonest gnats in Egypt, Palestine and Syria. It is so universal that it is hardly necessary to give localities. This and the following species were found up to 4,500 feet in the Lebanon Mountains.

The larvae abound in water-barrels and other receptacles in gardens, surface wells, and covered and uncovered tanks and cisterns.

Theobaldia annulata, Schrank.

Much less common than the last-named, and absent from Egypt.

The strongly marked type form was taken at Ramleh, Palestine, and at Ain Sofar, Lebanon Mountains. In the Jordan Valley at 1,000 feet below sea-level, I found some specimens of a pale variety which agree with the Mesopotamian form, referred to in my paper on mosquitos of that region (Bull. Ent. Res. x, p. 325, 1920).

Theobaldia morsitans, Theo.

At the end of April 1920 some larvae were found in a pool at the bottom of a small quarry at Haifa. The species was not met with elsewhere.

[**Taeniorhynchus richiardii,** Fic.]

This species has been found in Palestine, at Jell Zahmûl, Huleh, by Dr. J. Cropper, but was not met with by the author.

Uranotaenia unguiculata, Edw.

Widely distributed in Egypt, and found in parts of Palestine. The larvae as a rule are only to be found in the larger swamps.

My thanks are again due to Dr. Guy A. K. Marshall, Director of the Imperial Bureau of Entomology, and Mr. F. W. Edwards, of the British Museum, for assistance in the identification and synonymy of certain of the species and forms mentioned above. Also to Mr. G. Storey, of the Egyptian Ministry of Agriculture, for information as to the distribution of mosquitos in Egypt.

A PRELIMINARY REVISION OF THE GENUS DOCIOSTAURUS, FIEB.

By B. P. Uvarov,

Assistant Entomologist, Imperial Bureau of Entomology.

The genus *Dociostaurus*, Fieb., which is synonymous with *Stauronotus*, Fisch., includes several species of locusts and grasshoppers injurious to agriculture in South-Eastern Europe, Central and Western Asia and North Africa, the well known Moroccan locust (*Dociostaurus maroccanus*, Thunb.) being one of the worst pests in Algeria, Tunisia, Asia Minor, the Caucasus and Turkestan. The systematics of the species of this genus are in a very unsatisfactory state, and this, together with the tendency of the species to individual variability, is the cause of many mistakes in their identification on the part of economic entomologists. The object of this paper is, therefore, to establish a more or less natural system of the species enabling everyone to identify them with certainty.

The materials upon which this work is based were assembled by me from different sources. First of all, I have worked out the collection of the Tiflis Museum (Caucasus), where very large series of *Dociostaurus* species from Transcaucasia and Persia are to be found. Then also the very rich collection of the Turkestan Entomological Station (in Tashkent) was placed at my disposal by the Director of this Station, V. Plotnikov. My friend N. Ikonnikov sent me large series of specimens from Turkestan, Bokhara, and other places, as well as the material in the Museum of Moscow University. The Entomologist of the Entomological Station in Bairam-Ali (Transcaspia), D. A. Smirnov, collected for me in that locality, where I myself had also collected previously. My own collection contains extensive series of this genus taken by myself in Uralsk province (S. E. Russia), Northern Caucasus and Transcaucasia. Very helpful for me was the kindness of Messrs. C. & I. Bolivar, who sent me for study several Spanish and North African representatives of this genus, as well as the types of species described by I. Bolivar. To all the above-named gentlemen I wish to express here my cordial thanks for the loan of material which has enabled me to accomplish this revision.

The genus *Dociostaurus* was described in June 1853 by Fieber (Lotos, iii, p. 118), and in the same year, but in November, by Fischer (Orthoptera Europaea, pp. 297, 351) under the name *Stauronotus*; Fischer's name has been generally accepted, but it must give way to *Dociostaurus*, Fieb., according to the law of priority. W. F. Kirby in his catalogue (Synon. Cat. of Orthoptera, iii, pp. 152-154, 1910) includes in the genus *Dociostaurus* 12 species. Later on, I. Bolivar described in 1911 *D. kervillei* from Persia and in 1917 *D. dantini* from Morocco; Kirby and Waterhouse included (Fauna Brit. India, Acrid., pp. 117–120, 1914) in this genus five species described by Walker under *Stenobothrus*. Prof. Stchelkanovzev described in 1909 *D. tartarus* (Izvestia Varshav. Universit., Warsaw, 1909, p. 34), which is omitted in Kirby's Catalogue. Lastly, F. Werner published in 1913 one more species from Egypt under the name of *D. gracilis* (Zool. Jahrb., Syst., xxxiv, p. 220).

Thus the number of species of the genus *Dociostaurus* reached 19. This number, however, must be reduced to 10 only, since some of the species do not really belong to this genus and others again must be regarded as synonymous, as follows :—

Oedipoda histrio, Fisch. Wald. (Orth. Imperii Rossici, p. 311, pl. 32, fig. 6) belongs, according to Fischer Waldheim, to the section of his genus "*Oedipoda*" with three keels on the pronotum, the two lateral keels being straight or nearly so; this is not the case in the genus *Dociostaurus*, one of its chief generic characters being the strongly angulated side keels of the pronotum. I am of opinion that Fischer Waldheim's species is merely one of the numerous colour forms of *Calliptamus italicus*, L.

All five of Walker's species, as a study of the types in British Museum clearly shows, belong to the genera *Aulacobothrus*, Bol. and *Leva*, Bol., and not to *Dociostaurus*.*

Stauronotus australis, Bol., can hardly belong to this genus, since it is described from tropical West Africa, while all representatives of the genus are palaearctic in their distribution.

Stauronotus hauensteini, Bol., and *Stauronotus kervillei*, Bol., are synonymous with *Dociostaurus crassiusculus*, Pantel, as I am convinced from a study of Bolivar's types.

Stauronotus tartarus, Stchelk., is not an independent species, but a geographical race of *Dociostaurus crucigerus*, Ramb., as is shown below.

Dociostaurus gracilis, Werner, though very unsatisfactorily described, is most likely to be synonymous with *D. genei*, Ocsk.

Unfortunately but few species of this genus (for example, *maroccanus*) are sharply characterised, while the rest of them are extremely variable individually, their variability being expressed not in coloration or dimensions only, but to some extent in morphological characters as well. In consequence of this, it is quite easy to make mistakes in studying representatives of such extremely variable species as *crassiusculus* or *anatolicus*, unless very large series of specimens are available. Though I have been able to study rather long series (more than one thousand specimens altogether), I still think it impossible to give yet a full monograph of the genus, and this revision must be regarded as but a preliminary one.

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* The synonymy of these species of Walker's is as follows :—

Leva apicalis (Walker).

1871. *Stenobothrus apicalis*, Walker, Cat. Derm. Salt. Brit. Mus., v, Suppl., p. 80.
1871. *Stenobothrus turbatus*, Walker, *l.c.* p. 81.
1910. *Dociostaurus apicalis*, Kirby, Syn. Cat. Orth., iii, p. 154, no. 11.
1910. *Dociostaurus turbatus*, Kirby, *l.c.*, p. 154, no. 12.
1914. *Dociostaurus apicalis*, Kirby, Fauna Brit. India, Acrid., p. 117, no. 135, fig. 90.
1914. *Dociostaurus turbatus*, Kirby, *l.c.*, p. 118, no. 136.

Leva mundus (Walker).

1871. *Stenobothrus mundus*, Walker, Cat. Derm. Salt. Brit. Mus., v, Suppl., p. 79.
1871. *Stenobothrus epacromoides*, Walker, *l.c.*, p. 81.
1914. *Dociostaurus mundus*, Kirby, Fauna Brit. India, Acrid., p. 119, no. 137.
1914. *Dociostaurus epacromoides*, Kirby, *l.c.*, p. 119, no. 138.
? 1918. *Stauroderus exemplaris*, I. Bolivar, Rev. R. Acad. Sc. Madrid, xvi, p. 380.

Aulacobothrus decisus (Walker).

1871. *Stenobothrus decisus*, Walker, Cat. Derm. Salt. Brit. Mus., v, Suppl., p. 80.
1914. *Dociostaurus decisus*, Kirby, Fauna Brit. India, Acrid., p. 120, no. 139, fig. 91.

The genus *Dociostaurus* is purely palaearctic in its distribution, and none of the species is to be found beyond the borders of the Palaearctic Region. The centre of development of the genus is to be looked for in the dry table-lands of Western and Central Asia, where the largest number of species occurs and where they are especially disposed to individual variability. From there different species spread (and are spreading continually) in all directions, but more especially into the plains of the vast palaearctic desert belt, extending through Northern Africa, and South-western and Central Asia, in the fauna of which species of *Dociostaurus* present one of the most characteristic features. The distribution of each species will be discussed below in more detail.

Key to the Species.

1(10). Hind femora attenuate, narrow, slightly incrassate at the base. Pronotum constricted in the middle; white stripes not dilated in metazona, or altogether absent.

2 (3). Elytra extending considerably beyond the apex of abdomen. Antennae in both sexes but slightly extending beyond the hind margin of pronotum. Fore tibiae thickened. (Foveolae of the vertex narrowed anteriorly. Front vertical; its ridge above ocellum sulcate in male and plane in female. Hind femora with three very distinct black spots outwardly and black-knees. Hind tibiae sanguineous, with base pale.—Length of body, ♂ 20–28, ♀ 28–38; of elytra, ♂ 20–27, ♀ 25–36; of hind femora, ♂ 15, ♀ 20 mm.)

1. *maroccanus*, (Thunb.)

3 (2). Elytra not or scarcely reaching the apex of hind femora. Antennae of male one and half times or even twice as long as the head and pronotum taken together; antennae of female extending considerably beyond the hind margin of pronotum. Fore femora not thickened.

4 (5). Head not at all or but slightly prominent above pronotum. Foveolae of the vertex longer than wide. Front in male slightly inclined, with flat ridge, in female vertical with ridge convex above ocellum. Elytra reaching the apex of hind femora. Hind femora with three sharp black spots

2. *crucigerus* (Ramb.).

a(*d*). Hind tibiae red. Black marks very distinct.

b(*c*). General habitus slender; head not thick. (Length of body, ♂ 14–16, ♀ 18–23; of elytra, ♂ 9–11, ♀ 15–17; of hind femora, ♂ 10, ♀ 13 mm.)

2*a*. *crucigerus crucigerus* (Ramb.).

c(*b*). General habitus more clumsy; head thick. (Length of body ♂ 12–16, ♀ 20–24; of elytra ♂ 8–10, ♀ 12·5–15; of hind femora ♂ 10·2, ♀ 12–15 mm.) .. .. 2*b*. *crucigerus hispanicus* (Bol.).

d(*a*). Hind tibiae pale. Coloration more or less pale, with the black and white markings indistinct or totally absent. (Dimensions as in *crucigerus*)

2*c*. *crucigerus tartarus* (Stchelk.).

5 (4). Head very prominent above, especially in male. Foveolae of the vertex as long as wide. Front in male strongly, in female markedly reclinate. Elytra not or scarcely reaching the apex of hind femora.

6 (7). Occiput without carina in its middle. Hind tibiae bluish. Foveolae of the vertex not narrowed anteriorly. (Antennae in both sexes one and half times as long as head and pronotum together. General coloration pale greyish, with grey markings ; hind femora with rather distinct grey spots.—Length of body, ♂ 12, ♀ 15–17 ; of pronotum, ♂ 2–3, ♀ 3 ; of elytra, ♂ 10–12, ♀ 13–14 ; of hind femora, ♂ 6–7, ♀ 9–11 mm.) .. 3. *genei* (Ocsk.).

7 (6). Occiput with a short but distinct longitudinal carina in the middle.

8 (9). Small, slender. Foveolae of the vertex strongly narrowed anteriorly. Frontal ridge in male impressed along its whole length, in female quite flat. Hind tibiae yellowish or bluish, without dark ring near the base. (General coloration brownish grey or clay-coloured. Antennae in male twice, in female one and half times as long as head and pronotum together. Wings hyaline or bluish.—Length of body, ♂ 12–14, ♀ 13–16 ; of elytra, ♂ 7–10, ♀ 11–13 ; of hind femora, ♂ 8–10, ♀ 11–13 mm.)
4. *albicornis* (Eversm.).

9 (8). Larger and heavier built. Foveolae of the vertex not or but slightly narrowed anteriorly. Frontal ridge in male quite flat, in female convex above ocellum, but flat and disappearing below it. Hind tibiae greyish, bluish or rose, with a black or dark ring near the base. (General coloration very variable. Antennae in male twice as long as in female but a little longer than head and pronotum together. Wings rosy or bluish.—Length of body, ♂ 18–27, ♀ 23–32 ; of elytra, ♂ 12–16, ♀ 15–20 ; of hind femora, ♂ 12–15, ♀ 15–20 mm.) .. .. 5. *anatolicus* (Krauss).

10 (1). Hind femora short, wide, rather incrassate at the base. Pronotum cylindrical, not constricted in the middle ; white stripes in metazona dilated.

11 (14). Rather slender, with head prominent above. Hind tibiae never red.

12 (13). Foveolae of the vertex longer than wide, not narrowed anteriorly, and contiguous at the apex. Frontal ridge in male plane, with slight impression below ocellum (female unknown). (Black markings on pronotum and hind femora sharp. Hind tibiae yellowish.—Length of body, ♂ 12·5 ; of elytra, ♂ 5·5 ; of hind femora, ♂ 9 mm.) .. .. 6. *dantini*, Bol.

13 (12). Foveolae of the vertex nearly as long as wide, narrowed anteriorly. Frontal ridge in male sulcate for its whole length, in female flat and slightly impressed near ocellum. (General coloration clay-like, with very indistinct castaneous markings. Hind tibiae bluish.—Length of body, ♂ 14, ♀ 21 ; of elytra, ♂ 5–8, ♀ 8–15 ; of hind femora, ♂ 10, ♀ 14 mm.)
7. *plotnikovi*, sp. n.

14 (11). Clumsy, with thick head, not prominent above. Hind tibiae red or sanguineous.

15 (18). Lateral carinae of pronotum present not only on metazona, but also on fore part of prozona. ♂ : anal segment with two large rounded contiguous lobes behind, covering the base of the supra-anal plate ; the latter rounded, with apex attenuate. ♀ : anal segment far wider than long ; supra-anal plate triangular, its length equal to its basal width. Hind tibiae coral-red.

16(17). Smaller. Foveolae of the vertex distinctly impressed, markedly narrowed anteriorly. Front rather reclinate; frontal ridge in profile straight. (Yellowish-grey or clay-coloured, with more or less distinct grey and pale markings; lateral lobes of pronotum with a black square spot in the middle. Antennae in male one-half, in female slightly, longer than head and pronotum together. Elytra not longer than abdomen, but very often far shorter.—Length of body, ♂ 12–18, ♀ 18–26; of elytra, ♂ 7–11, ♀ 9–18; of hind femora, ♂ 9–10, ♀ 12–15 mm.) .. 8. *crassiusculus* (Pantel).

17(16). Larger. Foveolae of the vertex but slightly impressed, nearly square. Front nearly vertical; frontal ridge in profile convex. (Straw-yellow, with sharp grey and black markings. Antennae in female as long as head and pronotum together, in male a little longer. Elytra reaching the middle of abdomen.—Length of body ♂ 23, ♀ 32; of elytra, ♂ 8, ♀ 13; of hind femora, ♂ 13, ♀ 18 mm.) .. .. 9. *kurdus*, sp. n.

18(15). Lateral carinae of the pronotum present on metazona only. ♂: anal segment with two small, widely separated lobes behind; supra-anal plate triangular, not attenuate at the apex. ♀: anal segment as long as wide; supra-anal plate longer than its basal width. Hind tibiae sanguineous. (Clayish grey or brown, dull, with indistinct grey and pale markings. Lateral lobes of pronotum with a small square black spot in the middle. Elytra reaching the apex of abdomen.—Length of body, ♂ 16–18, ♀ 23–25; of elytra, ♂ 11–12, ♀ 14–16; of hind tibiae, ♂ 11, ♀ 15 mm.)

10. *kraussi* (Ingen.).

Annotated Catalogue of Species.

1. **Dociostaurus maroccanus** (Thunb.).

1815. *Gryllus maroccanus*, Thunberg, Mém. Acad. Petersb., v, p. 244.

1824. *Gryllus maroccanus*, Thunberg, *l.c.*, ix, pp. 399, 425, no. 91.

1825. *Gryllus cruciatus*, Charpentier, Horae Entom., p. 137.

1832. *Oedipoda cruciata*, Brullé, Exped. Morée, Ins., p. 92, no. 63, pl. 30, fig. 2.

1836. *Acrydium cruciatum*, Costa, Fauna Regni Napoli, Acrid., p. 37, no. 17, pl. 5, fig. 1, *A*, *b*, *c*.

1846. *Oedipoda vastator*, Fischer Waldheim, Orth. Imp. Ross., p. 312, no. 30, pl. 14, fig. 1.

1853. *Dociostaurus cruciata*, Fieber, Lotos, iii, p. 118 (*partim*).

1853. *Stauronotus cruciatus*, Fischer, Orth. Europ., p. 352 (*partim*), pl. 17, fig. 11, *a*, *b*.

1854. *Dociostaurus cruciata*, Fieber, Syn. Eur. Orth., p. 18, no. 1 (*partim*).

1873. *Stauronotus maroccanus*, Stål, Rec. Orth., p. 111, no. 1.

1882. *Stauronotus maroccanus*, Brunner v. Wattenwyl, Prodr. Europ. Orth., p. 136, no. 1.

1910. *Dociostaurus maroccanus*, Kirby, Syn. Cat. Orth., iii, p. 152, no. 1.

This species was described by Thunberg in 1815 and 1824, and redescribed twice since—by Charpentier as *Gryllus cruciatus** and by Fischer Waldheim as *Oedipoda*

* I am obliged to Dr. W. Ramme, who kindly studied for me Charpentier's type of *cruciatus* in the Berlin Museum and informed me that it is identical with *maroccanus*, Thunb.

vastator. Fieber and Fischer evidently described this species (under *cruciatus*) together with *crucigerus* of Rambur, which is a quite distinct species; and the same mistake has been repeated even by Brunner, who says that *maroccanus* is a very variable species, which is not the case. In fact, I had the opportunity of studying many hundreds of specimens from different localities and may say that the individual or geographical variability in this species is extremely small, and it is very constant in all its characters. It can very easily be recognised by the aid of the key given above. From its nearest relative, *D. crucigerus*, it may be distinguished by its long elytra, short antennae and thickened (in males) fore femora, besides its different dimensions. It is interesting to mention that females during the period of oviposition gradually change their coloration, which becomes dull clay-coloured, the black markings turning to light brown. This coloration might be regarded as protective while the female is sitting on the ground, but it is more likely to depend on physiological causes. The coloration of the males changes in this period as well, but to a far less degree.

Geographical Distribution. The range of distribution of the Moroccan locust includes North Africa, Southern Europe, Syria, Palestine, Arabia, Mesopotamia, Asia Minor, Armenia, Persia and the Aralo-Caspian plains. Within this vast region there are to be found several places where this species finds most favourable natural conditions and where it becomes a serious pest of agriculture, breeding in large masses and acquiring swarming habits.*

2. **Dociostaurus crucigerus** (Ramb.).

1838. *Gryllus crucigerus*, Rambur, Faune Entom. d'Andal., ii, p. 86, no. 13.

1848. *Oedipoda brevicollis*, Eversmann, Addit. quaedam laevia ad Fisch. Wald. celeb. Orth. Ross., p. 11, tab. A, fig. 4.

1853. *Dociostaurus cruciata*, Fieber, Lotos, iii, p. 118 (*partim*).

1853. *Stauronotus cruciatus*, Fischer, Orth. Europ., p. 352 (*partim*).

1853. *Stauronotus crucigerus*, Fischer, *l.c.*, p. 356, no. 5.

1854. *Dociostaurus cruciata*, Fieber, Syn. Europ. Orth, p. 18, no. 1 (*partim*).

1859. *Stauronotus cruciatus*, Eversmann (*nec* Charp.), Bull. Soc. Nat. Moscow, xxxii (1), p. 137.

1860. *Stauronotus genei*, Türk (*nec* Ocsk.), Wien. Ent. Mon., iv, p. 86, no. 3.

1862. *Stauronotus annulipes*, Türk, *l.c.* vi, p. 81.

1867. *Stauronotus brevicollis*, Frivaldsky, Ertek Termész. Kör., i (12), p. 162, no. 1, pl. 6, fig. 10.

1882. *Stauronotus brevicollis*, Brunner v. Wattenwyll, Prodromus Europ. Orth., pp. 136, 137, no. 2, pl. 5, fig. 30, A, B.

1910. *Dociostaurus brevicollis*, Kirby, Syn. Cat. Orth., iii, p. 153, no. 4.

Rambur's description of *Gryllus crucigerus* leaves no doubt that he had before him not *D. maroccanus*, Thunb. (known at that time as *cruciatus*, Charp.), but another species distinguished by its smaller size, shorter elytra and with the lateral carinae of the pronotum present on the prozona as well as on the metazona—*i.e.*

* The biology of *D. maroccanus* is fully described by W. La Baume in a recently published book.

the species described ten years later by Eversmann as *Oedipoda brevicollis*. Afterwards, however, Fieber and Fischer, who evidently did not know Rambur's species, confused it, as well as *brevicollis*, Ev., with *cruciatus*, Charp. (*maroccanus*, Thunb.).

This miscomprehension of *crucigerus* has been accepted by all following writers: even Eversmann himself in 1859 regarded his *brevicollis* as synonymous with *cruciatus*, Charp. Later on *brevicollis*, Ev., was raised to specific rank by Frivaldsky (1867), but the identity of *brevicollis* and *crucigerus*, Ramb., has never been recognised. Rambur's name, however, has ten years priority over *brevicollis* and must therefore be adopted. The same species has been again described in 1860 by Türk under *Stauronotus genei* (*nec* Ocsk.), and two years later the author changed this name, as preoccupied by Ocskay, into *annulipes*.

This species in its typical form is easily recognisable from its nearest relative—*maroccanus*—by the characters given above, which are very constant.

Geographical distribution. The area of distribution of this species occupies the southern (Mediterranean) parts of Europe, South Russia, Southern Siberia, Turkestan, Transcaspia, the Caucasus, Asia Minor, Persia and North Africa. It is to be mentioned, however, that the species is to be sub-divided into three different geographical races (subspecies), as follows:—

2a. **Dociostaurus crucigerus hispanicus,** Bol.

1898. *Stauronotus brevicollis* var. *hispanicus*, I. Bolivar, Ann. Sci. Nat. Porto, v, p. 14.

This subspecies, peculiar to Spain, is distinguished from the typical form by its more heavy habitus and especially its thick head (thanks to the kindness of Messrs. Bolivar I have had the opportunity of studying this form). It would be of interest to examine a large series of specimens from Southern France, whence Rambur's type came. If specimens from this locality are identical with *hispanicus*, then the Eastern European form, which I take now for the typical, must have another name, and *brevicollis*, Ev., might be applied to it as a subspecific name.

2b. **Dociostaurus crucigerus crucigerus**, Ramb.

The typical form occurs over the whole of Southern Europe, South Russia, Caucasus (except the Eastern plains of Ciscaucasia and Transcaucasia) and Southern Siberia.

2c. **Dociostaurus crucigerus tartarus,** Stschelkan.

1909. *Stauronotus tartarus* (Sauss. in litt.), Stschelkanovzev, Izvestia Imper. Varshav. Univers., Warsaw, 1909, p. 34, no. 22.

——. *Stauronotus genei*, auctorum (*nec* Ocsk.), *partim*.

This south-eastern desert subspecies is easily recognised by the colour of its hind tibiae, as well as the rather indistinct and extremely variable general coloration. On account of its pale tibiae it is very often confused with *D. genei*, Ocsk., which has good morphological differences from it. The area of distribution of this race lies in desert plains of the Aralo-Caspian basin, Persia, Mesopotamia and Northern Africa; in fact it populates the whole Eremian subregion of the Palaearctic Region.

The economic importance of *Dociostaurus crucigerus*, with its subspecies, is not so great as that of *maroccanus*, since it is a non-swarming and non-migratory species, but still it is one of the injurious grasshoppers and does some damage to grass and corn crops in Spain and Western Siberia, together with different species of *Stenobothrus* and other grasshoppers.

3. **Dociostaurus genei** (Ocsk.).

1832. *Gryllus genei*, Ocskay, Acta Acad. Leop.-Carol., xvi (2), p. 961.

1853. *Acridium pygmaeum* (Bonelli in litt.), Fischer, Orth. Europ., pp. 352, 353, tab. xvii, fig. 11c, 11d.

1910. *Dociostaurus genei*, Kirby, Syn. Cat. Orth. iii, p. 154, no. 8.

? 1913. *Dociostaurus gracilis*, Werner, Zoolog. Jahrb., Syst., 34, p. 220.

Closely related to *albicornis*, Ev., but always recognisable by the lack of the longitudinal carina on the vertex. From *D. crucigerus tartarus* it may be distinguished by the prominence of the upper part of the head.

Geographical Distribution. This is not quite clear, since the species has been often confused with *albicornis* and *crucigerus tartarus*, but it seems that it is a native of the desert plains of Western Asia and North Africa, occurring also in some isolated places in Southern Europe.

There is nothing known about the economic importance of this species.

4. **Dociostaurus albicornis** (Eversm.).

1848. *Stauronotus albicornis*, Eversmann, Addit. quaedam laevia ad Fisch. Wald. Orth. Ross., p. 10, no. 6, pl. A, fig. 3.

1910. *Dociostaurus albicornis*, Kirby, Syn. Cat. Orth., iii, p. 157, no. 9.

Though the difference between *albicornis* and *genei* is rather considerable, it seems desirable that an examination should be made of large series of specimens of both species, which may then prove to be conspecific.

Geographical Distribution. Not so extensive as that of *genei*, since it is known only from the Aralo-Caspian basin; its occurrence in Germany, recorded by Azam (Bull. Soc. Ent. France, 1913, p. 218) is almost certainly based on a wrong determination or a mistake in date.

The economic importance of this species is unknown.

5. **Dociostaurus anatolicus** (Krauss).

1896. *Stauronotus anatolicus*, Krauss, Zoolog. Jahrb., Syst., ix, p. 560, no. 7, pl. 8, fig. 1.

1896. *Stauronatus anatolicus* var. *castaneopicta*, Krauss, *l.c.*, p. 562, no. 7a, pl. 8, fig. 2, 2 A, B.

1907. *Stauronotus anatolicus* var. *castaneopicta*, Adelung, Horae Soc. Entom. Ross., xxxviii, p. 51, no. 10, pl. 1, fig. 2.

1910. *Dociostaurus anatolicus*, Kirby, Syn. Cat. Orth., iii, p. 153, no. 7.

An extremely variable species in its size, relative dimensions and coloration. The form described and figured by Krauss and Adelung under the name v. *castaneopicta* is remarkable for the coloration of the head and especially of the pronotum and elytra, on which large velvet-castaneous spots are to be seen on a straw-yellow ground.

Geographical Distribution. *D. anatolicus* occurs in Asia Minor, Eastern and Southern Transcaucasia, the whole Aralo-Caspian basin and Persia.

In some localities of Turkestan it occurs in large quantities, though it does not form swarms, and may cause some damage to grass; no attacks on cultivated crops, however, have been recorded.

6. **Dociostaurus dantini,** I. Bol.

1914. *Dociostaurus dantini,* I. Bolivar, Mem. R. Soc. Españ. Hist. Natur., viii (5a), p. 186.

A very distinct species, as I have been able to ascertain by a study of the unique type specimen.

Geographical Distribution. Described from Morocco.

7. **Dociostaurus plotnikovi,** sp. nov.

The short diagnosis of this new species given above may be completed by the following description:—

Form slender. General coloration clay-yellow, with obsolete grey markings. Head elongate, prominent above (especially in male); eyes elongate; front in male strongly reclinate and wholly sulcate, in female markedly reclinate, flat, with a slight impression near the ocellum. Antennae in male one and half times as long as head and pronotum together, in female only a little longer. Foveolae of the vertex markedly impressed, nearly as long as wide, narrowed in front. Typical sulcus of pronotum placed behind the middle; hind margin of pronotum rotundate; disk obsolete castaneous (very often only in metazona) with pale lateral cross-shaped lines, which are triangularly widened on the metazona; lateral lobes with an obliterated grey or castaneous spot in the middle. Elytra about as long as abdomen, unicolorous or with scarcely distinct grey spots. Hind femora with typical spots greyish, obsolescent. Hind tibiae bluish or pale. ♂: anal segment with two small rotundate widely separated lobes; supra-anal plate rotundato-triangular; subgenital plate short, with blunt apex, very hairy. ♀: anal segment wider than long; supra-anal plate rotundato-triangular. (Dimensions, see Key.)

Geographical Distribution. This species has been sent to me from the Turkestan Entomological Station by the Director, V. Plotnikov, from Turkestan (Golodnaya Steppe) and Bokhara (Mirshade-Karatag), where it occurs sometimes in considerable quantities, and its larvae even form migrating swarms, causing damage to different cultivated crops.

8. **Dociostaurus crassiusculus** (Pant.).

1886. *Stauronotus crassiusculus,* Pantel, Ann. Soc. Esp. Hist. Nat., xv, p. 237, pl. 2, fig. 1.

1893. *Stauronotus hauensteini*, Bolivar, Rev. Biol. Nord. France, v, p. 480.
1894. *Stauronotus hauensteini*, Giglio-Tos, Boll. Mus. Torino, ix (191), p. 2.
1896. *Stauronotus hauensteini*, Krauss, Zoolog. Jahrb., System., ix, p. 562, no. 9, pl. 8, fig. 3.
1898. *Stauronotus crassiusculus*, Bolivar, Ann. Sci. Nat. Porto, v, p. 13, 14.
1902. *Stauronotus crassiusculus*, Navas, Bol. Soc. Esp. Hist. Natur., ii, p. 335, no. 3.
1910. *Dociostaurus hauensteini*, Kirby, Syn. Cat. Orth., iii, p. 153, no. 2.
1910. *Dociostaurus crassiusculus*, Kirby, *l.c.*, p. 153, no. 6.
1911. *Dociostaurus kervillei*, Bolivar, Bull. Soc. Sci. Nat. Rouen, xlvii, p. 36.
1913. *Stauronotus crassiusculus*, Pant., var. *cappadocicus*, Azam, Bull. Soc. Ent. France, 1913, p. 219.

D. crassiusculus, Pantel, was described from Spain, and *hauensteini*, Bol., from Asia Minor, but I have most carefully studied topotypic specimens of both species and could not find any difference between them. I had very large series of this species from Asia Minor, Transcaucasia and Persia, which enable me to state that it is very variable in its dimensions and coloration, though not in morphological characters, which are very stable. *D. kervillei*, described by Bolivar more recently, is but a small and rather light-coloured form of the same species, as I am convinced from a study of the type specimen. The variety described by Azam is a mere individual aberration which is not worth a distinctive name.

Geographical Distribution. This is as yet not fully known. It seems that this species has two separate areas of distribution : one in Spain and another in Western Asia (Asia Minor, Armenia, Eastern Transcaucasia, Persia, Syria) ; but it is quite possible that it occurs in North Africa as well. If even these two areas are actually separated, there is nothing unnatural in such distribution of a species, since we know that there existed once a closer connection between the eastern and western parts of the Mediterranean countries than is now the case.

There are no records concerning the economic importance of this species.

9. **Dociostaurus kurdus,** sp. nov.

There is nothing to be added to the short diagnosis of this species given above, since it agrees in all essential characters with *D. crassiusculus*, the differences being given in the key to the species. These differences are, in fact, so few that I should have been inclined to treat *kurdus* as only a geographical form of *crassiusculus* were it not that it has also some important morphological features, and I prefer to regard it in the meantime as a distinct species.

Geographical Distribution. I had a number of specimens of both sexes from Muséék and Vezne, in Kurdistan, taken by P. Nesterov in June and July 1914.

10. **Dociostaurus kraussi** (Ingen.).

1897. *Stauronotus kraussi*, Ingenitsky, Horae Soc. Entom. Ross, xxxi, p. 63, pl. 7.
1910. *Dociostaurus kraussi*, Kirby, Syn. Cat. Orth., iii, p. 153, no. 3.

This species is very well characterised by numerous morphological features, and is quite easy to recognise. It is not very variable in dimensions and little more so in coloration, but all the morphological characters are very constant.

Geographical Distribution. *D. kraussi* is distributed all over the Kirghiz Steppes (north from the Caspian Sea), Turkestan, Transcaspia, Eastern Ciscaucasia and South-western Siberia. In the latter country it is one of the commonest grasshoppers, being sometimes very injurious to pastures and corn crops.

A supplement to the synonymy of Dociostaurus maroccanus, *Thunb.*

In the course of rearranging the collection of *Locustidae* in the British Museum, I came across the type of *Epacromia oceanica*, Walker (Cat. Derm. Salt. Brit. Mus., *iv*, p. 779, No. 26, 1870), which has been included by Kirby (Syn. Cat. Orth., iii, p. 193, No. 12) in the genus *Chortoicetes*, but is undoubtedly conspecific with *D. maroccanus*. The type specimen of *E. oceanica* bears the label "Sandw. I., Beechey"; but there are in the British Museum a few more undoubtedly palaearctic species bearing the same label, and the only explanation is that these specimens have been taken during Capt. Beechey's journey from Europe, *via* the Canaries, to the Sandwich Islands, most probably at the Canaries or at Madeira, and that they have been wrongly labelled.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st October and 31st December 1920, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. T. J. Anderson, Government Entomologist :—36 Culicidae, 199 Tabanidae, 96 *Stomoxys*, 242 other Diptera, 795 Coleoptera, 214 Hymenoptera, 2 Planipennia, 112 Lepidoptera, 10 species of Coccidae, 235 other Rhynchota, 41 Orthoptera, 12 Odonata, and 47 Ticks ; from Kenya Colony.

Mr. E. Ballard, Government Entomologist :—8 Microlepidoptera ; from Madras.

Mr. Cecil N. Barker, Durban Museum :—29 Bruchidae and 2 Hispidae ; from South Africa.

Capt. P. J. Barraud, Entomologist to the Egyptian Expeditionary Force :—1 *Dorylus* Ant and 5 Odonata ; from Palestine.

Dr. Chas. K. Brain :—2 Diptera ; from Stellenbosch, South Africa.

Division of Entomology, Pretoria :—6 Diptera, 52 Coleoptera, 8 Hymenoptera, and 49 Rhynchota ; from South Africa.

Mr. P. R. Dupont, Curator of the Botanic Station :—2 species of Coccidae ; from Seychelles.

Mr. T. Bainbrigge Fletcher, Imperial Entomologist :—150 Bees ; from India.

Mr. C. C. Gowdey, Government Entomologist :—7 Diptera, 59 Coleoptera, 135 Ants, 33 other Hymenoptera, 5 Lepidoptera, 10 Thrips, 38 species of Coccidae, 490 Aphididae, 7 other Rhynchota, 80 Isoptera, 5 Orthoptera, 5 Odonata, 7 Ticks, and 1 Scorpion ; from Jamaica.

Mr. G. F. Hill, Entomologist, Australian Institute of Tropical Medicine :—4 Isoptera ; from North Queensland.

Mr. M. Afzal Husain, Government Entomologist :—57 Jassid Bugs and 2 Orthoptera ; from the Punjab.

Mr. J. C. Hutson, Government Entomologist :—323 Ticks ; from Ceylon.

Dr. A. Ingram :—97 Culicidae, 100 Psychodidae, 8 *Auchmeromyia*, 9 *Cordylobia*, 180 other Diptera, 50 Siphonaptera, 3 Coleoptera, 2 Planipennia, 11 Lepidoptera, and 30 Mites ; from the Gold Coast.

Mr. G. W. Jeffery :—15 Lepidoptera ; from Lumbwa, Kenya Colony.

Dr. W. A. Lamborn :—4 *Cordylobia*, 64 Chalcids, and 21 Coleoptera ; from Tanganyika Territory : and 8 microscope-preparations of *Stegomyia scutellaris* infested with protozoal parasites, 52 other preparations, 19 Coleoptera, and 5 Orthoptera ; from the Federated Malay States.

Major W. F. M. Loughnan, R.A.M.C. :—A number of blood-sucking Chironomidae from Jamaica.

Dr. J. W. Scott Macfie :—Preparations of *Toxorhynchites* mosquitos ; from Accra, Gold Coast.

Mr. G. Mer, Jewish Health Bureau :—4 Culicidae and 2 Tabanidae ; from Palestine.

Mr. Norman C. E. Miller :—2 species of Coccidae ; from Morogoro, Tanganyika Territory.

Mr. W. H. Patterson :—1,589 Coleoptera and 17 Lepidoptera ; from the Gold Coast.

Mrs. W. H. Patterson :—46 Diptera, 1,735 Coleoptera, 29 Lepidoptera, and 25 Rhynchota ; from the Gold Coast.

Mr. A. H. Ritchie :—463 Coleoptera ; from Jamaica.

Mr. W. Robson, Curator of the Botanic Station :—Specimens of the leaf blister mite of cotton ; from Montserrat.

Senhor A. F. de Seabra :—3 Tabanidae, 4 other Diptera, 101 Coleoptera, 25 Hymenoptera, and 28 Rhynchota ; from San Thomé.

Mr. F. R. Shepherd, Agricultural Superintendent :—Specimens of the leaf blister mite of cotton ; from St. Kitts.

Mr. Hubert W. Simmonds :—47 Diptera, 2 Hymenoptera, 5 Micro-lepidoptera, and 4 Rhynchota ; from Fiji.

Mr. S. H. Skaife :—59 Bruchid beetles and 12 Chalcid parasites ; from South Africa.

Mr. O. H. Swezey, Entomologist to the Hawaiian Sugar Planters' Association :—12 Weevils ; from Hawaii.

Mr. F. W. Urich :—365 Coleoptera, 2 Hymenoptera, 6 species of Coccidae, and 20 Aleurodidae ; from San Thomé.

Mr. R. Veitch :—10 Coleoptera, 8 Hymenoptera, 21 Lepidoptera, and 11 Rhynchota ; from Fiji.

Wellcome Bureau of Scientific Research :—6 Coleoptera ; from Peru.

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